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ABSTRACT

This ninth grade student manual was developed to be used in conjunction with some of the experimental science activities described in the teacher's guide. It contains laboratory worksheets for: (1) measurement; (2) basic energy concepts; (3) heat energy; (4) light; (5) sound; (6) electricity; and (7) present and future energy resources. Additional worksheets give instructions for a home study (the growth of bean seeds) and on the use of the periodic table. Also included are the following: (1) a guide to reading electric meters; (2) a student polling sheet and data sheets which deal with nuclear issues; and (3) a chart relating careers in energy to level of schooling needed. (TW)

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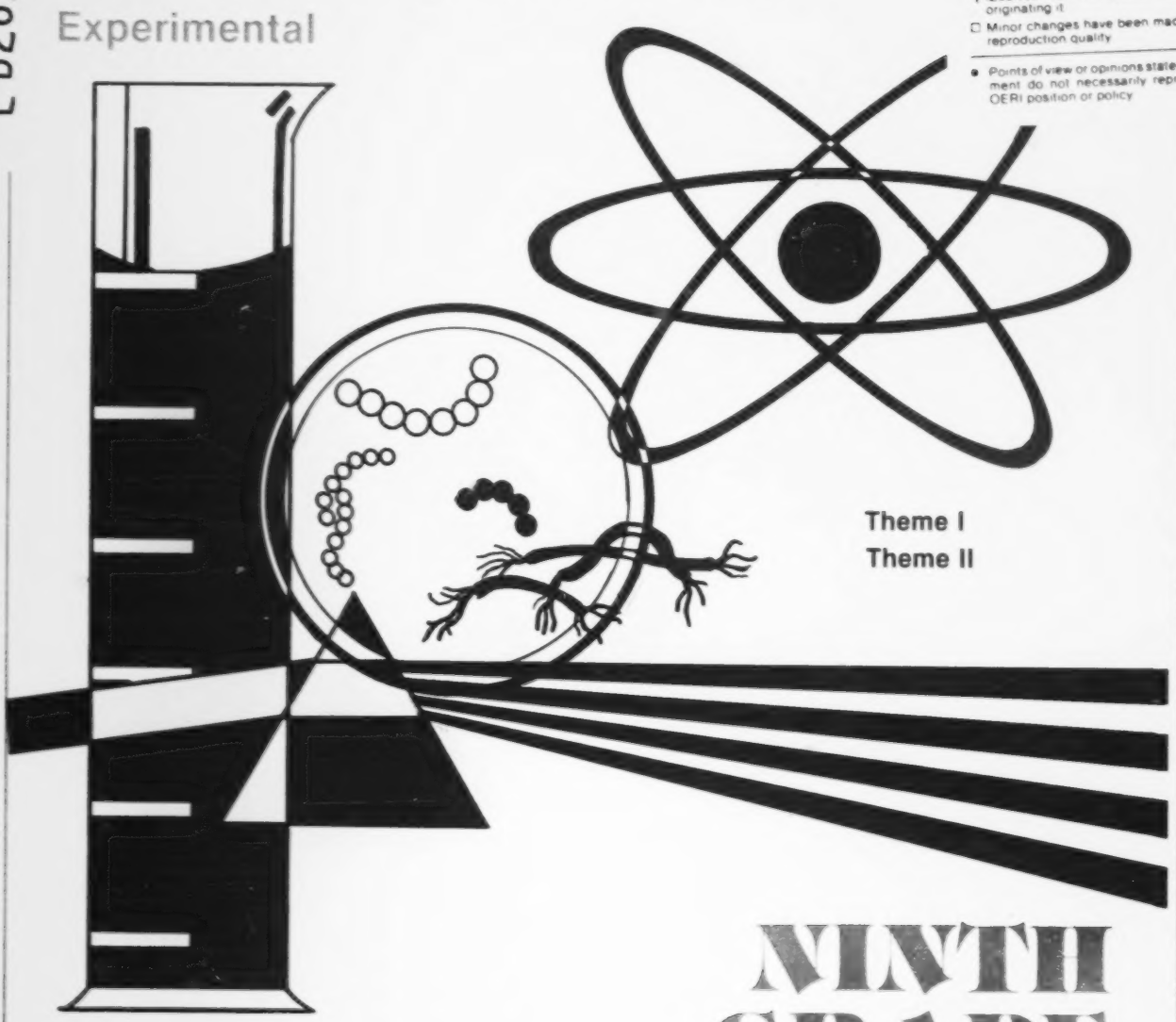
GENERAL SCIENCE

Experimental



Theme I
Theme II

NINTH GRADE

Student Laboratory Manual

NEW YORK CITY BOARD OF EDUCATION
Office of Curriculum Development and Support
Division of Curriculum and Instruction

SE 048 364

New York City Board of Education

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NOTE

These worksheets are intended for use in conjunction with the lessons included in Ninth Grade General Science, Themes I and II. To facilitate the use of these materials, each worksheet has been coded to correspond to a specific theme and lesson. In addition to the worksheets, other selected materials are included. Copies of all these materials also appear in the teacher's guide.

LABORATORY WORKSHEET 1.1

NAME _____ CLASS _____ DATE _____

PROBLEM: Why is it difficult to perform a complicated task even though detailed written directions are supplied?

MATERIALS: A piece of blank paper measuring 22 cm by 28 cm., scissors, ruler.

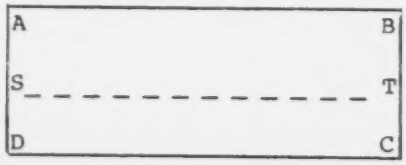
INTRODUCTION: When a scientist verifies (checks the accuracy) of a fellow scientist's experiment, much depends upon his ability to read and follow directions. Let's see how well you can follow the directions that are on this sheet.

PROCEDURE

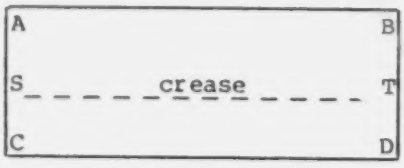
1. Cut out a rectangular piece of paper measuring 12 cm by 24 cm. Discard the scraps.

2. Label the four corners as shown.

3. Fold the paper in half, the long way. Crease it. Spread the paper out and write "S" and "T" on the middle crease.



4. Fold AB to ST and crease. Fold CD to ST and cease line. Press down and turn your model over.

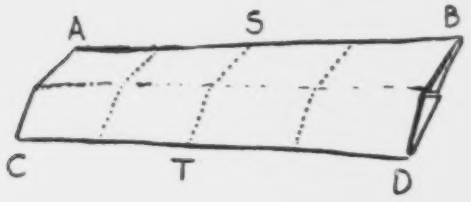


LABORATORY WORKSHEET 1.1 (continued)

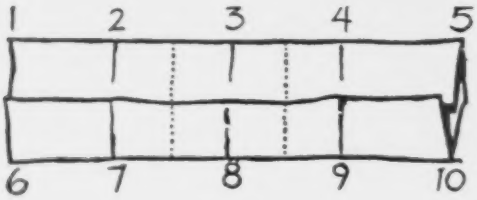
NAME _____

5. Fold AC to BD. Now fold to ST. Crease and unfold what you have done. Fold BD to ST and Crease. Unfold your work and turn the model over.

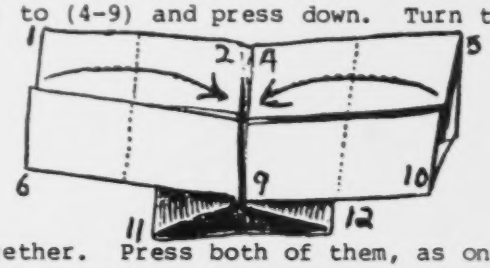
6. Mark your model as follows.



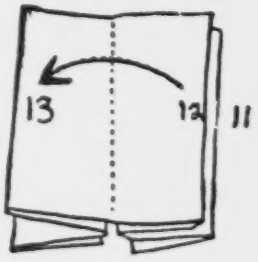
7. Fold (2-7) to (3-8) at the dotted line. Leave (1-6) alone. Fold (4-9) to (3-8) without changing (5-10). Press down.



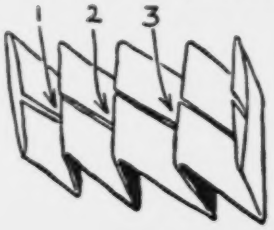
8. Add points 11 and 12. Fold (1-6) to (2-7) at the dotted line. Press down. Fold (5-10) to (4-9) and press down. Turn the model over.



9. Fold 11 and 12 together. Press both of them, as one piece, to point 13 [add 13, if necessary]. Stand the model up.

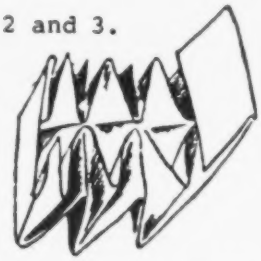


10. At the points 1, 2, and 3, lift the flaps at the bottom and pleat using the ruler.



LABORATORY WORKSHEET 1.1 (continued)

11. Repeat with the flaps opposite to 1, 2 and 3.



12. Press, and fold as shown above. Lift up the end piece to form a flap.

    You have just made a MISER'S PURSE. This purse makes your dollars go a long way when you open it!

SUMMARY/HOMEWORK

1. What difficulties did you experience in making the MISER'S PURSE?

2. Did these directions help you to make the model?

3. Would following these directions more closely have helped you make the model? Why?

4. Which is more important in following directions, speed or accuracy? Justify your answer.

5. How is following directions on a lab sheet similar to reading an assignment in your textbook?

LABORATORY WORKSHEET 1.2

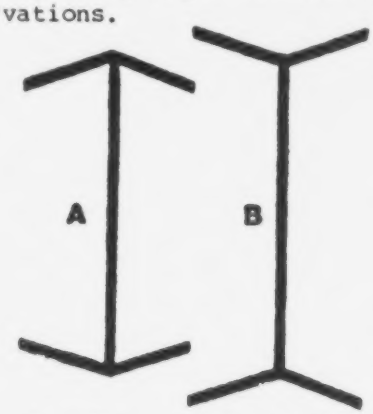
NAME _____ CLASS _____ DATE _____

PROBLEM: How accurate is my sense of sight?

MATERIALS: Metric ruler

INTRODUCTION: If you didn't have enough time to see the extra "THE" on the poster your teacher showed you, you will have additional chances to prove how well you see. The important thing is to discover if your eyesight is accurate and can be trusted to make observations.

PROCEDURE

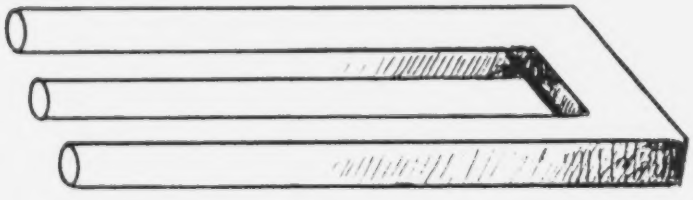


1. Look at vertical lines A and B. Which is longer? _____

   Use the ruler and check your answer. Which line does the ruler tell you is the longer? _____

2. What is wrong with the center rod in this picture? _____

   _____

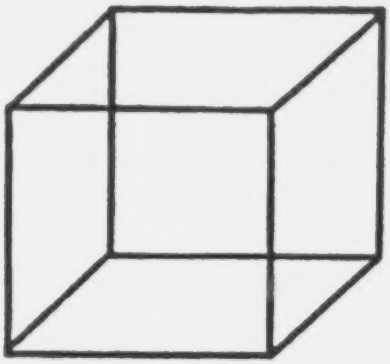


NAME _____

Why is it impossible to make this out of wood in your school shop?

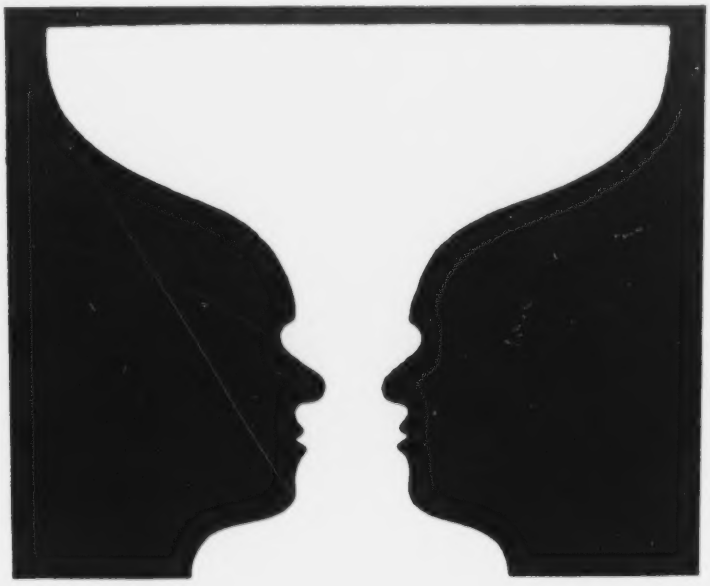
_____

3. Look at the corner of the box closest to you for a minute. Which corner is now the closest to you? _____



4. What are you looking at here, two people face to face or a wine glass?

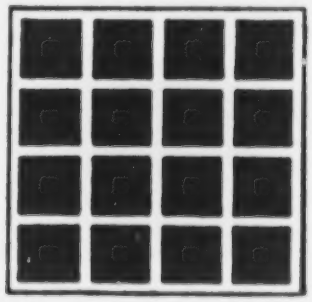
_____



LABORATORY WORKSHEET 1.2 (continued)

NAME _____

5. Look at the white strips, especially where they intersect. Where did the circular gray shadows come from? Why do they keep moving? _____



6. What conclusion can you arrive at after examining your data (answers)?

7. How does this experiment explain why several witnesses to a bank robbery may describe the bandits differently?

8. How should we decide which witness (if any) to believe?

LABORATORY WORKSHEET 1.3

NAME _____ CLASS _____ DATE _____

PROBLEM: What equipment will we be using in science this year?

INTRODUCTION: The purpose of this lesson is to acquaint you with some of the equipment that you will be using this year.

MATERIALS: Variety of laboratory equipment.

PROCEDURE

1. Carefully examine each piece of equipment on the tray at your table.
2. Using the chart on the following page, and the reference sheet "Common Scientific Equipment," write on the chart the names of as many pieces of scientic equipment as you can. Then write the purpose of each item in the space provided on the chart.

SUMMARY/HOMEWORK

1. Why is it necessary to have many different kinds of equipment in a laboratory?

_____

_____

2. Choose three of the items. Tell what they are used for? Why is each well suited for its use?

_____

_____

LABORATORY WORKSHEET 1.3 (continued)

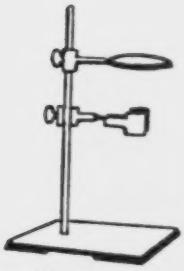
NAME _____

Laboratory equipment

Name	Use

14

COMMON SCIENTIFIC LABORATORY EQUIPMENT


RING STAND

BUNSEN BURNER

TEST TUBE

BEAKER

FLORENCE FLASK

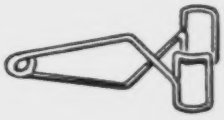
ERLENMEYER FLASK

THISTLE TUBE

GAS COLLECTING BOTTLE

REAGENT BOTTLE

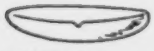
FUNNEL


TEST TUBE CLAMP

TONGS

SPATULA

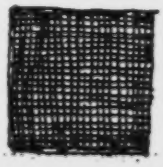
TRIPOD

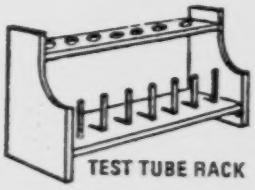

EVAPORATING DISH

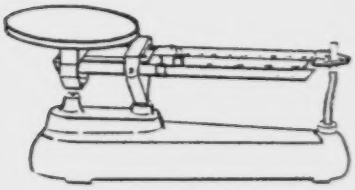
CRUCIBLE

WATCH GLASS

FORCEPS


WIRE GAUZE


TEST TUBE RACK


TRIPLE BEAM BALANCE

MORTAR AND PESTLE

TRIANGLE

GRADUATED CYLINDER

TEST TUBE BRUSH

BAR MAGNET

MEDICINE DROPPER

15

LABORATORY WORKSHEET 1.4

NAME_____ CLASS_____ DATE_____

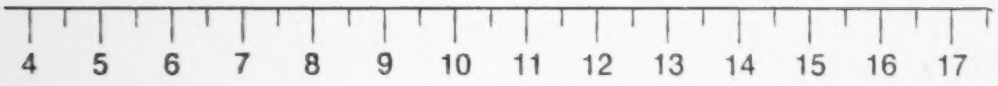
PROBLEM: How do we use the meterstick?

INTRODUCTION: The meter is the basic unit of length in the metric system. A meterstick is a convenient measuring instrument used for measuring lengths in that system. Today, we will study the meterstick and learn how to use it properly.

MATERIALS: Meterstick, metric ruler.

PROCEDURE

1. Examine the meterstick (a sample section appears below).



_____

a. You can see many lines dividing the stick into equal spaces. How many numbered spaces are there on a meterstick? _____

b. How many of these numbered spaces make up 1 meter? _____

c. Each numbered space represents the fraction of a meter called a _____.

d. Why is it impractical to number the smaller spaces on the meterstick also?

_____

_____

2. Use the meterstick to measure the items assigned by your teacher. Record your results.

LABORATORY WORKSHEET 1.4 (continued)

NAME _____

Object Name	My Measurements	Other Groups' Measurements		
1. length of room				
2. height of your desk				
3. width of door				

3. Examine your small metric ruler. How does its numbering differ from that of the meterstick?

_____

_____

a. Find the space between the fifth and sixth centimeter marks on the metric ruler. How many small spaces are there in that centimeter? _____

b. How many of these small units would there be in one meter? _____

How did you determine this? _____

_____

c. Each of these spaces is called a millimeter. Why is it given this name?

_____

_____

d. Each millimeter space is 1/_____ of a centimeter. (Hint: See your answer to 3a.)

e. Why is the number 10 important in the metric system?

_____

_____

f. Measure three small objects with the metric ruler and enter your measurements on the following chart.

LABORATORY WORKSHEET 1.4 (continued)

NAME _____

Object Name	My Measurements	Other Groups' Measurements		
1. length of 5th finger (start at 3rd crease)				
2. pen				
3. diameter of a quarter				

SUMMARY/HOMEWORK

1. Why would different groups get different measurements for the length of the room? For the length of a person's fifth finger?

2. The United States is the only major country in the world not completely using the metric system. Today you have seen some of the advantages of this system. Write a persuasive letter addressed to your local representative in Congress explaining why we should switch to this system. Give arguments and examples.

LABORATORY WORKSHEET 1.5

NAME_____ CLASS_____ DATE_____

PROBLEM: How can we make more precise metric measurements of length?

INTRODUCTION: It is often necessary to read between the lines of a metric ruler. You will now have an opportunity to learn and apply this skill.

MATERIALS: Metric stick, metric ruler.

PROCEDURE

1. Using the meterstick, measure and record your lab partner's height.

   _____m _____cm _____mm

2. Using the metric ruler, measure the length of your partner's right thumb. Record this length below:

   _____m _____cm _____mm

SUMMARY/HOMEWORK

1. The basic unit of length measurement in the metric system is the _____.
2. How many centimeters are there in a meter?_____
3. How many millimeters are there in a meter?_____
4. How many millimeters are there in a centimeter?_____
5. Why would the millimeter be a poor unit to measure the distance between New York and Chicago?

   _____

   _____

6. Suggest a way to make long distance measurements using metric units.

   _____

   _____

LABORATORY WORKSHEET 1.6

NAME _____ CLASS _____ DATE _____

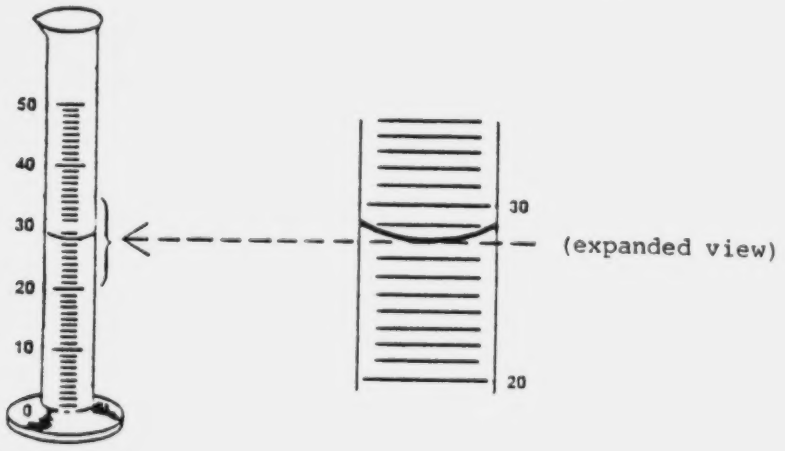
PROBLEM: How can we measure the volume of a liquid in a test tube?

INTRODUCTION: The liter measures the space occupied by a liquid. A milliliter is a subunit of a liter. Today you will become familiar with the basic laboratory instruments used to measure the volume of liquids.

MATERIALS: Test tube rack with four 6 in. test tubes, graduated cylinder, battery jar marked at the 1 liter level, medicine dropper, 250 ml beaker filled with water.

PROCEDURE

1. Examine the graduated cylinder (a sample section appears below).



   a. Into how many units is the cylinder divided? _____

   b. What is each of these units called? _____

   c. How many of these units are needed to fill a liter container? _____

   d. How many times must you fill the graduate to have one liter of liquid? _____

2. Fill a test tube to the top with water.

   a. Pour the water into a graduated cylinder. How much water did the test tube hold? _____ ml

LABORATORY WORKSHEET 1.6 (continued)

NAME _____

b. Note the curve of the water surface in the graduated cylinder. This is called the meniscus (see diagram). The reading is taken at the bottom of the meniscus. Be sure your eyes are level with the meniscus when you take your reading.

c. Read the water level in the graduated cylinder again. _____ml
Does this answer differ from your answer to 2a? _____. Why?

_____

_____

d. Partially fill your emptied test tube. Estimate how much water it contains. _____ml

e. Add the water in the test tube to the water already in the graduated cylinder.
How much water does the cylinder now contain? _____ml
How much water did your test tube contain? _____ml
Why is an estimation (as above) not always desirable?

_____

_____

3. Empty the water from the graduated cylinder into the battery jar at the front of the room.

a. Record the amount of water held by the battery jar on the chart on the board.

b. How much water must be added to fill the empty battery jar to the one-liter line? _____ml

c. Name two items that you can purchase in the supermarket that are marked in liters:

_____; _____.

4. (Optional)

a. Fill a medicine dropper with water from the beaker.

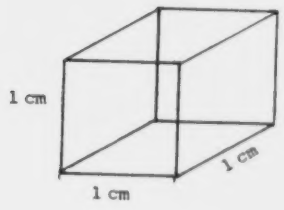
b. Slowly drop the water (counting the drops) into an empty graduated cylinder to reach the 2 ml line. How many drops of water are there in a ml?_____
How many ml are there in a drop of water?_____

LABORATORY WORKSHEET 1.6 (continued)

NAME _____

SUMMARY/HOMEWORK

1. Examine the cube below and answer the questions:



length _____ cm
width _____ cm
height _____ cm
volume _____ cm^3
(length x width x height)

a. How many units of a graduated cylinder would liquid from this cube fill?_____

b. What is the name of each of the units on the graduated cylinder?
_____.

c. How many cubes of liquid would it take to fill a liter container?
_____.

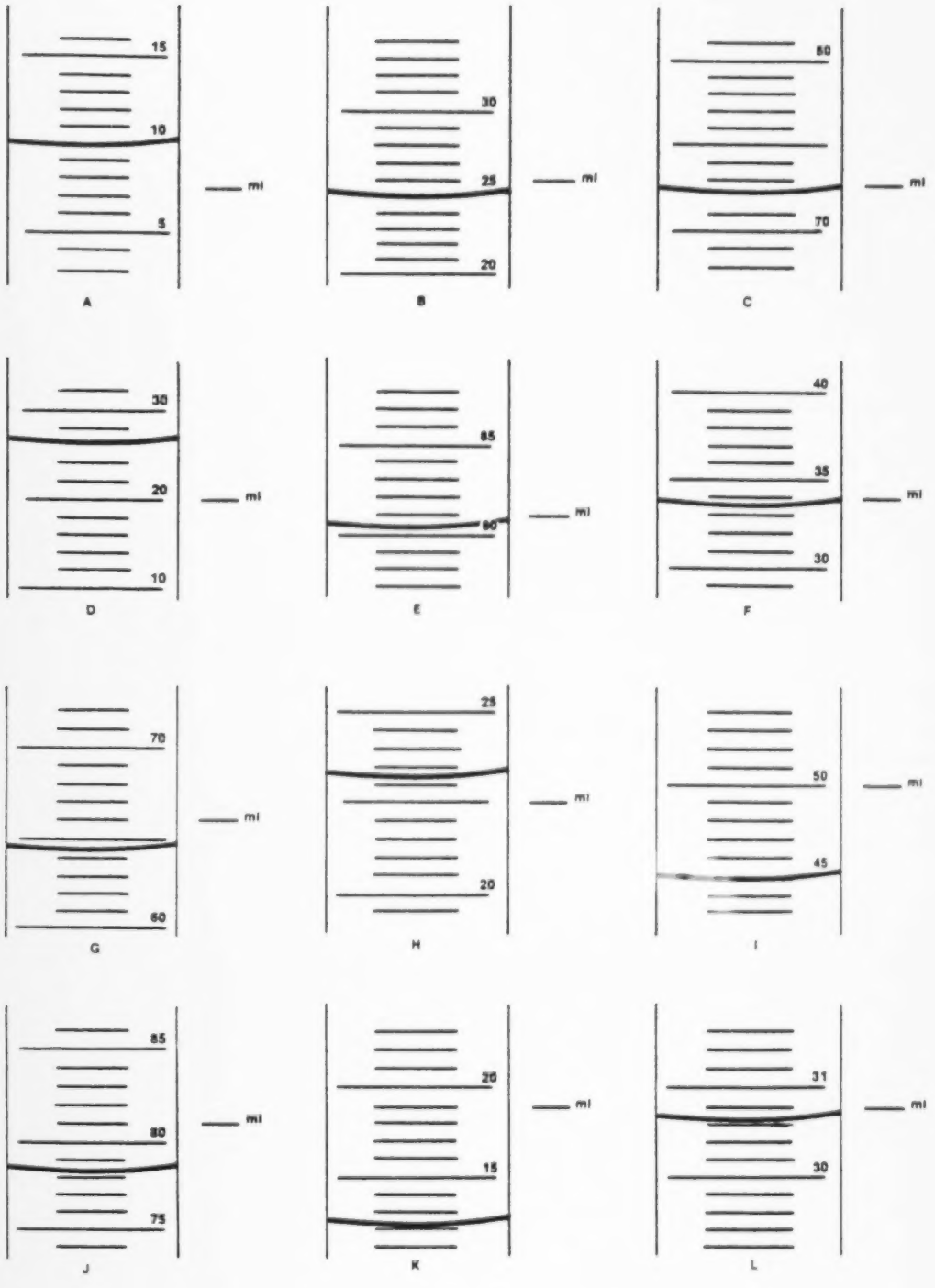
2. How are cubic centimeter units related to liters?

_____

_____

3. Study each diagram on the following page and then record the number of milliliters in the proper place. If the meniscus falls between two lines, estimate your answer.

LABORATORY WORKSHEET 1.6 (continued)



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LABORATORY WORKSHEET 1.7

NAME _____ CLASS_____ DATE_____

PROBLEM: How can we measure the temperature of our classroom accurately?

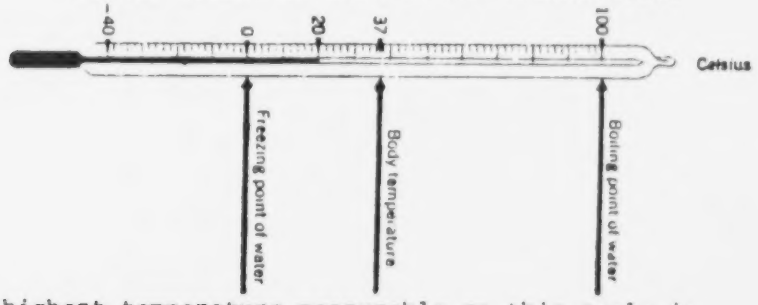
MATERIALS: Celsius thermometer, mercury or alcohol, beakers of boiling water on tripods or on hot plates, wire gauze, tongs, beakers of ice.

INTRODUCTION: An instrument that measures temperature in degrees is the thermometer. Today you will be studying a temperature scale called the Celsius scale. This is now the universal temperature scale (used throughout the world) and is part of the metric system of measurement. A unit of heat measurement is the calorie. It is THE AMOUNT OF HEAT THAT WILL RAISE THE TEMPERATURE OF ONE MILLILITER OF WATER BY ONE DEGREE ON THE CELSIUS SCALE.

PROCEDURE

1. Examine the temperature scale on the thermometer, an illustration of which appears below. Then answer questions 1a-1c, which refer to the illustration.

DO NOT TOUCH THE BULB OF THE THERMOMETER!



a. The highest temperature measurable on this scale is _____.

b. The lowest temperature measurable on this scale is _____.

c. The total number of degrees on this temperature scale is _____.

2. Allow the thermometer to rest on your table for about one minute. Then record the temperature it registers in the column marked Classroom Readings, Room Temperature, on the chart attached to this lab sheet. Why is this called the room temperature?

_____

_____

LABORATORY WORKSHEET 1.7 (continued)

NAME _____

3. Measure your body temperature by the following method. (If time permits, other members of your lab group may also try this.) Place the bulb of the thermometer in the center of your armpit and lower your arm, holding it as close to your body as you can. (Did you know that this is how temperature is taken in most of the world?) Be careful to support the thermometer so that it does not tip or break. After three minutes, record your body temperature on the chart.

4. Place the thermometer carefully into the boiling water on the demonstration table. Record the temperature of the boiling point of the water on the chart.

5. Allow the bulb of your thermometer to cool before you place it in ice water. (Do you know why this is necessary?) Then place it into the beaker of ice water at your table. Record the Ice Temperature on your chart.

6. Complete the chart by finding the difference between the average Celsius temperatures found by the rest of the class and those you have recorded.

CELSIUS TEMPERATURE CHART READINGS

	Your Values	Class Average	Difference	Reasons for difference
ROOM TEMPERATURE (^{o}C)				
BODY TEMPERATURE (^{o}C)				
TEMPERATURE OF BOILING WATER (BOILING POINT)				
TEMPERATURE OF ICE WATER (FREEZING POINT)				

LABORATORY WORKSHEET 1.7 (continued)

NAME _____

SUMMARY

1. The Celsius scale used to be called the centigrade scale.

   a. The prefix "centi" means _____.

   b. If a centimeter is one-hundredth of a meter, why is this temperature scale called the centigrade scale?

SUMMARY/HOMEWORK

1. Compare a fever thermometer, an outdoor-indoor type thermometer, an oven thermometer, or any other temperature measuring instrument you may have at home to those you studied in class today?

2. The thermometers you have at home may use a Fahrenheit scale. If so:

   a. Find the boiling point, freezing point, and body temperature used on the Fahrenheit scale.

   b. Calculate the number of degrees on the Fahrenheit scale between the boiling and freezing points of water. Why is this number more difficult to remember than the comparable temperature differences on the Celsius scale?

LABORATORY WORKSHEET 1.8

NAME_____ CLASS_____ DATE_____

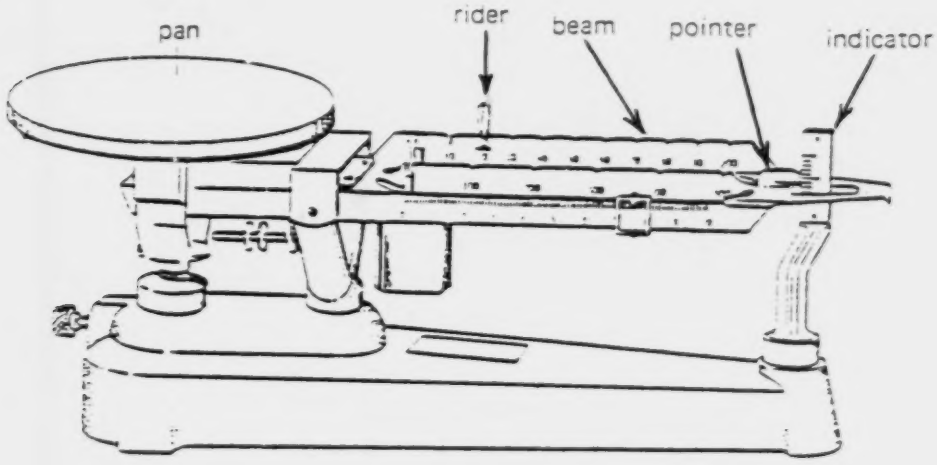
PROBLEM: How can we measure the mass of a glass of water accurately?

INTRODUCTION: A unit of mass in the metric system is the GRAM (g). Metric mass is measured in the science laboratory by the measuring device called a triple beam balance. Today you will learn how to use a triple beam balance to measure the masses of common objects.

MATERIALS: Triple beam balance, standard masses, beaker, water, coins, and other objects, drinking glass.

PROCEDURE

1. Examine the triple beam balance on your table. A simplified diagram of the balance appears below:



a. What is the function of the balance pan?

_____

b. What is the function of the beams with riders?

_____

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NAME _____

c. How do the three beams differ from each other?

_____

d. Examine each beam and its rider. What unit of measure is indicated by all three beams?

_____

e. Why must the riders on two of the beams be in the notches rather than in between the notches?

_____

f. When you move the rider one notch on the middle beam, how much additional mass is indicated?

_____

g. When you move the mass on the rear beam, how much additional mass is indicated?

_____

h. Why is this called a triple beam balance?

_____

i. What is the mass of the heaviest object that can be massed on this balance? How did you arrive at this answer?

_____

2. The triple beam balance is a delicate instrument that, if mishandled, can lose its accuracy. Do not play with the balance. Now you will test the balance.

a. Select a standard mass and place it on the balance pan.

b. Adjust the riders on each beam until a balance is reached. How do you know when this happens?

_____

NAME _____

c. Record the mass indicated by the riders of your balance: _____ Is it the same as the number marked on the standard mass? Explain why the two values may not be identical.

_____

_____

3. Practice makes perfect

a. Mass the empty water glass. Record its mass. _____
Fill the glass with water. What is the total mass? _____
What was the mass of the water in the glass ? _____

b. How many glasses of water did your teacher drink if he drank 946 grams? _____

c. Select at least three other items to mass. (You may use some coins, your pen, pencil, ruler, etc.)

d. List the items in order of the RELATIVE masses that you estimate by holding them in your hands. How does this use of your hands use the same principle as the balance?

_____

_____

Items by estimated mass	Mass using a balance
Lightest	
Heaviest	

Were the estimated masses correct? If not, explain. _____

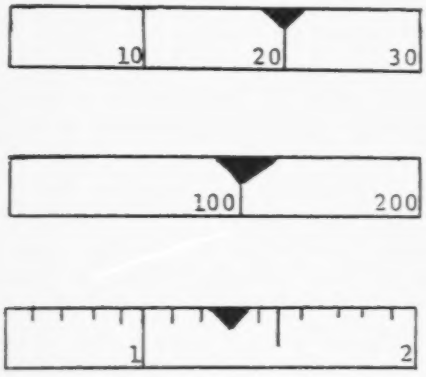
_____

LABORATORY WORKSHEET 1.8 (continued)

NAME _____

SUMMARY/HOMEWORK

1. Below is a representation of the beams of a balance after placing an orange on the pan. What is the mass of the orange? _____ grams.



2. Design a beam balance which you could use to find your mass in metric units.

LABORATORY WORKSHEET 1.9

NAME_____ CLASS_____ DATE_____

PROBLEM: How are a gram, a milliliter, and a centimeter related?

INTRODUCTION: We have seen that there is a relationship between the units of volume and linear measurements (1 = 1 ml). Today you will see how the gram, the milliliter and the centimeter are related in the metric system.

MATERIALS: Triple beam balance, graduated cylinder, water.

PROCEDURE

1. How much does a milliliter of water weigh?

   a. Mass an empty 25 ml graduated cylinder on your balance and record the mass. _____ grams.

   b. Fill the graduate to the 10 ml mark and mass it again. Record the mass of the graduate and the water. _____ grams.

      Calculate the mass of the water alone? _____ grams.

      If 10 ml of water has a mass of _____ grams, then 1 ml of water must have a mass of _____.

   c. Empty the graduated cylinder and fill it with water to the 5 ml line.

      Mass it with the water and record the weight. _____ grams.

      The mass of 5 ml of water alone is _____ grams.

      The mass of 1 ml of water is _____ grams.

   d. Mass 1 ml of water. Why is it more accurate to mass more than 1 ml and then divide the mass by the number of milliliters?

      _____

      _____

e. How are the milliliter and the gram of water related?

_____

_____

2. Complete the Sentences

a. One milliliter of water has a mass of _____gram(s).

b. One milliliter of water equals _____ cubic centimeter(s).

c. One cubic centimeter of water has a mass _____gram(s).

d. A milliliter is a unit of (volume, length, weight). Select one.

e. A gram is a unit of (volume, length, mass). Select one.

f. A centimeter is a unit of (volume, length, weight). Select one.

g. _____ cm^3 = _____ ml = _____ g [For water only.]
how many? how many? how many?

SUMMARY/HOMEWORK

1. Explain how the units of length, volume, and mass are related in the metric system.

2. The Canadian dollar has a different value than the United States dollar. How do we know that the Canadian gram has exactly the same value as the United States gram?

STUDENT SHEET

LETTERS TO A FRIEND

NAME _____

Fill in the blanks in the two letters that Juanita wrote to her friend. Appropriate units may be selected from the following list:

gram	meter	liter	millimeter
kilogram	centimeter	milliliter	

October 2, 19___

Dear _____

Boy, was I suprised this morning when I stepped on the scale. I found that my mass was 60 _____. I couldn't believe my eyes. I used a tape measure and found my waist measured 70 _____. Do you think this is too much for someone who is 1.7 _____ tall? I decided to go on a diet and exercise.

For breakfast I had 120_____ of orange juice, 30_____of cereal with 100_____of milk. After breakfast, I walked 1,500_____.

I really hope this works. I will write you soon to let you know if I lost any weight.

Your friend,

Juanita

- -

October 9, 19___

Dear _____

I have great news. In just one week I have lost 950 _____ and lost 2 _____ from my waist. Never again will my breakfast consist of 500 _____ of soda and 250 _____ of potato chips.

Your friend,

Juanita

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LABORATORY WORKSHEET 1.10

NAME_____ CLASS_____ DATE_____

PROBLEM: How good are your measuring skills?

INTRODUCTION: In our most recent lessons, you have acquired a number of measuring skills. Today you will have an opportunity to demonstrate these skills under test conditions.

You will be graded on accuracy, technique, and group cooperation. Answers must be written in appropriate units in the spaces provided.

Before you begin, read the entire Procedure section carefully and plan the approach you will take to arrive at the correct answer.

MATERIALS: Triple beam balance, metric ruler, graduated cylinder, beaker of water, empty container.

PROCEDURE

1. Measure the height of the empty container. _____
2. Measure the width of the empty container. _____
3. Measure the depth of the empty container. _____
4. Using the measurements above, calculate the volume of your container. _____
5. Calculate the mass of 123 ml of water. _____
6. Pour 123 ml of water into your container and actually measure the mass of this water. _____
7. How does your calculated mass of 123 ml of water compare with its actual mass? _____

HOME LABORATORY STUDY

THE GROWTH OF BEAN SEEDS

NAME_____SCIENCE CLASS_____

MATERIALS

1. mung beans, or other large, quickly germinating seeds
2. two plastic cups, (5 oz)
3. clear plastic food wrap
4. absorbent paper toweling
5. water

DIRECTIONS FOR GROWING BEAN SEEDS

1. Place some moistened paper toweling on the bottom of each growth container. (Be certain that the toweling is NOT soaking wet).
2. Place three bean seeds on top of the moist material in each container.
3. Cover each container with clear plastic food wrap.
4. Place one of the containers in a drawer, closet, or warm, dark corner. Place the second container in the refrigerator.
5. EACH DAY, check each cup to determine if water is needed. (DO NOT over-water, or allow to dry out. Paper towel should remain moist at all times.) Remember to moisten those in the refrigerator as well as those in the warm, dark place.
6. Using the form which follows (and any additional paper you may need), keep a careful record of observations that you make each day. It is a good idea to record your observations when you remoisten the seeds. Be certain to observe your seeds each day of the growth period. REMEMBER, IF NO CHANGE OCCURS, THIS IS AN OBSERVATION TOO!
7. The growth experiment will continue for five days (or more, if your teacher prefers). Your laboratory report on this experiment is due in class on _____ (DAY), _____ (DATE). All parts of the report must be completed. You may do this as the experiment proceeds, or when all observations have been completed.
8. Your grade for this experiment will count as a test. You will not be graded on your results, but on how you have recorded your results and how you have used the SCIENTIFIC METHOD of discovery.

DO NOT THROW YOUR MATERIALS AWAY. YOU WILL BE REQUIRED TO BRING YOUR RESULTS TO CLASS TOGETHER WITH YOUR LABORATORY REPORT.

LABORATORY REPORT

DAY	DATE	OBSERVATIONS	
		REFRIGERATED CUP	WARM CUP (kept in drawer or closet)
1			
2			
3			
4			
5			

This laboratory report should contain the DESIGN AND CONCLUSION of your home study experiment involving the growth of bean seeds. All information should be obtained from the ACTUAL SETUP OF YOUR EXPERIMENT, YOUR OBSERVATIONS, and the CONCLUSIONS YOU REACH at the end of the study. Use the SCIENTIFIC METHOD outlines developed in class to guide you in writing this report.

LABORATORY WORKSHEET 1.11

NAME_____ CLASS_____ DATE_____

PROBLEM: What is wrong with this experiment?

INTRODUCTION: This is a report of an actual experiment on crop damage due to acid rain done by Thomas M. Rathier. This experiment was reported in the Fall 1983 issue of "Frontiers of Plant Science."

PROCEDURE

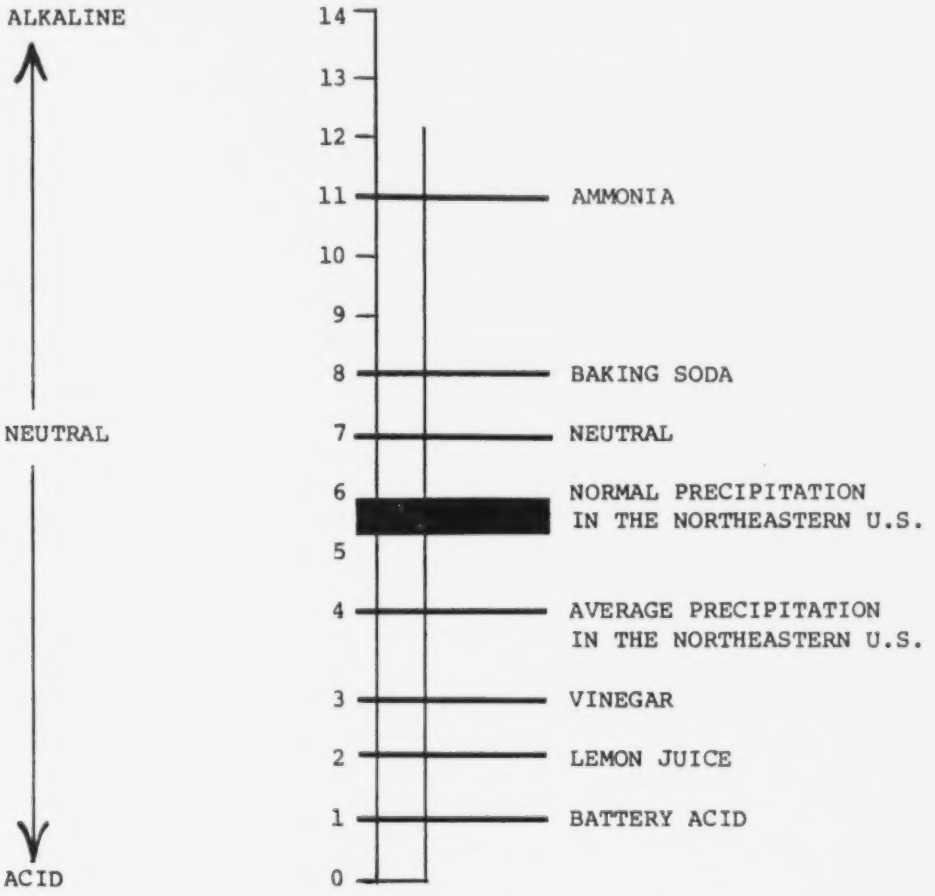
1. Does acid rain damage crops? If so, what does the damage look like and can it affect the appearance or yield of crops? Although popular reports on acid rain often mention damage to plants, there is little experimental evidence to confirm or deny such reports. Therefore, I performed an experiment using tobacco as the test crop.

2. I chose tobacco for two reasons. First, its leaves are sensitive to damage by ozone and other air pollutants. Second, much of the tobacco grown in Connecticut depends on the appearance of its leaves for its value: a single blemish or mark can make a normally valuable leaf nearly worthless.

3. Acid rain was made by adding nitric and sulfuric acids to tap water to produce six treatments with "rain" at pHs* of 2.0, 2.5, 3.0, 3.5, 4.0, and 5.6. Since unpolluted rain has a pH of 5.6 and rain in Connecticut has an average pH of about 4.3 to 4.4, these treatments are drastic.

4. * pH is a measure of how acid or alkaline a liquid may be. pH varies from 0 to 14. A pH of 7.0 is neutral (neither acid nor alkaline). If the pH is below 7, the solution is acidic. The closer the pH is to 0, the greater is the acidity. Look at the chart that follows. Find the pH for vinegar and for battery acid.

NAME _____



5. Each treatment was applied to the leaves of tobacco twice a week for one to five weeks. The plants were grown in containers with trickle irrigation to prevent irrigation water from washing the acid rain off the leaves. Also, the soil in the pots was covered to prevent the simulated acid rain from reaching the roots. The experiment was located outdoors at the Valley Laboratory in Windsor, but in a plastic house to prevent natural rainfall from washing the treatments off the leaves.

6. Damage was visible only on the plants receiving the most acidic rain at pH 2.0. Damage began as small yellow or green spots and progressed to bleached dead spots that enlarged with repeated applications. Continued application of the "rain" at pH 2.0 completely destroyed the tissue and caused a shot-hole appearance. Those leaves receiving two applications per week for five weeks were the most dramatically affected, whereas those receiving two applications for one week showed no additional damage after applications were stopped. Damage increased from about 30% of the leaves after two applications of pH 2.0 rain to 97% after ten applications.

LABORATORY WORKSHEET 1.11 (continued)

NAME _____

7. Damage from acid rain occurs only where water gathers for extended periods and the damage progresses from the exterior (outside) tissues to the interior (inside) tissues. It has been suggested that acidic water droplets remaining on leaves might evaporate and so concentrate their acidity. In my experience, all treatments had an opportunity to evaporate on the leaves, but again, damage only occurred with "rain" at pH 2.0.

8. Since rain in Connecticut has an average pH of 4.3 to 4.4, the likelihood of damage to crops is very slight.

SUMMARY/HOMEWORK

1. What was Dr. Rathier's hypothesis?

_____

_____

2. What was his control?

_____

_____

3. How many experimental groups did he use? _____

4. What precautions did he take to insure that his observations were correct?

_____

_____

5. What were his observations?

_____

_____

6. What vital bit of information concerning the number of plants tested was NOT included in this report?

_____

_____

NAME_____

7. Why is it important for us to know how many plants were tested?

_____

_____

8. What was his conclusion?

_____

_____

9. Can we accept this conclusion as being correct without the information we wanted in question #6? Explain your answer.

_____

_____

10. Is Professor Rathier's conclusion a positive conclusion or a negative one?

_____

_____

11. Can a negative conclusion of any experiment be valuable? Explain your answer.

_____

_____

LABORATORY REPORT

GROUP NAMES _____

State the problem.

What was your hypothesis?

What materials did you use?

Outline your experimental design. (This should include a step by step description of your procedure.)

What was your control?

Summarize your daily observations.

What conclusions did you reach as a result of your experiment?

LABORATORY WORKSHEET 2.1

NAME_____ CLASS_____ DATE_____

PROBLEM: What is in the sealed box?

MATERIALS: Sealed box (with two or three objects in it): iron filings, magnet, metric ruler, triple beam balance.

INTRODUCTION: All matter is made up of tiny particles called ATOMS. Atoms are so small that they cannot be seen even with the aid of a microscope. Then, how do we know about atoms? Scientists observe the properties of atoms by studying the behavior and characteristics of the many forms of matter. From the results of their studies, they make models of what they believe an atom is like. Today, you will learn how such models are made by studying some objects that YOU cannot see.

PROCEDURE

1. Select a box from the front of the room. The box will contain two or three objects, and must remain sealed. Record the number of the box on the chart below.

2. You must find out as much as you can about the objects in the box without opening the box. Keep a record of what you find on the chart. (Try listening, shaking, rolling, measuring, massing, balancing, magnetism, etc.)

3. When you have completed your observations, make a sketch of what you think each object in the box looks like. (Do not try to name the objects. Remember, this is a MODEL, NOT an accurate picture.) A list of boxes and objects may be made available to you so that you might check your results and see how close you came to "picturing" each object.

THE BOX NUMBER IS_____

Approximately how much of the box is occupied by empty space?_____

How did you arrive at this estimate?_____

_____

Are there any magnetic materials in the box?_____

How did you find out?_____

_____

LABORATORY WORKSHEET 2.1 (continued)

NAME _____

THE NUMBER OF OBJECTS IN THIS BOX IS PROBABLY _____

PROPERTY CHART FOR MYSTERY BOX

Project #	Size	Shape	Texture	Magnetic?	Material (Metal, plastic, etc.	Any Other Properties

SUMMARY/HOMEWORK

1. Describe the major problems you had in identifying the objects.

2. How does this relate to the problem scientists faced when the model of an atom was first proposed?

LABORATORY WORKSHEET 2.2

NAME_____ CLASS_____ DATE _____

PROBLEM: How does burning affect iron's mass?

MATERIALS: Steel wool, forceps, alcohol lamp, ceramic pad (do not use asbestos), iron filings, Petri dish (half), safety glasses or goggles, triple beam balance.

INTRODUCTION: Elements are the simplest forms of matter. They are made up of atoms which are all the same. They cannot be broken down into simpler substances or changed chemically into anything else. Yet, in nature, most elements are rarely seen alone. They occur in combined forms known as compounds.

PROCEDURE

1. Examine the ball of steel wool. Record its properties on the chart attached to this worksheet.

2. Record the MASS of the steel wool on your chart. Obtain the MASS by placing the CERAMIC PAD on the balance and the steel wool on top of the pad. YOU MUST MASS BOTH TOGETHER.

3. Following the directions below, BURN your steel wool ball:

   a. Carefully light your alcohol lamp. [Caution: Follow your teacher's instructions.]

   b. Place the ceramic pad alongside the lamp.

   c. Hold the steel wool with the forceps. Place it in the lamp's flame, holding it close to the ceramic pad. [Do not tilt the alcohol lamp to heat the steel wool!]

   d. Once the steel wool has begun to glow, remove it from the flame and put the cover on the burner, holding the steel wool over the ceramic pad. Blow GENTLY until the glow disappears.

4. Observe how the burning process has CHANGED the physical properties of the steel wool. Add these observations to your chart.

5. Remass your steel wool ball and ceramic pad together. (Remember to keep it on the ceramic pad at all times. DO NOT TOUCH THE STEEL WOOL. IT MAY BE HOT AND STILL SMOLDERING.) Record the new mass of the steel wool on your chart.

LABORATORY WORKSHEET 2.2 (continued)

NAME _____

6. Interpret the results of burning the steel wool.

	STEEL WOOL AND PAD BEFORE BURNING	STEEL WOOL AND PAD AFTER BURNING
PHYSICAL PROPERTIES (Appearance only)		
MASS		

A. How has the process of burning "CHANGED" the steel wool?

_____

B. Why is the mass of the steel wool different before and after burning?

_____

_____

C. Write a WORD EQUATION to describe the "burning" process.

_____

_____

D. Why is burning often referred to as OXIDATION?

_____

_____

_____

E. What evidence do you have that the change in the steel wool is a "permanent" change?

_____

_____

LABORATORY WORKSHEET 2.2 (continued)

NAME _____

F. The substance that has formed is called a compound.

a. What would you name this compound? _____

b. Define COMPOUND. _____

_____

SUMMARY/HOMEWORK

1. Predict what would occur if the elements sodium and chlorine were placed in a test tube and heated.

2. Write a word equation that summarizes your prediction.

3. Compounds form as the result of chemical changes. Define CHEMICAL CHANGE.

LABORATORY WORKSHEET 2.3

MINI—LAB

NAME_____ CLASS_____ DATE_____

PROBLEM: How do atoms compare to each other?

MATERIALS: Clay "atom," paper clip probe.

INTRODUCTION: It is hard to imagine how small an atom is. More than one million of them, side by side, would only be as thick as this page. By working with a model designed to represent an atom, scientists discovered that atoms are made up of even smaller particles. Today, you will "probe" into a clay form of an atom model you design to see what you can learn about these particles.

PROCEDURE

1. Study the OUTER region of the atom. Examine it carefully with your finger tips. This area is often referred to as the ELECTRON CLOUD.

   Scientists shoot atomic particles at atoms to study atomic structure. In place of atomic particles you will use a probe made from a paper clip.

   _____

2. Use the paper clip "probe" to examine the INNER atom. Push the probe into or through the clay ten times. Probe with care.

   a. How is the center of the atom different from the outer area?

   _____

   b. Draw a "sketch" of the clay atom showing its INNER AND OUTER structure.

   c. Now cut open the clay atom and see how accurate your model was. Draw a "sketch" of the ACTUAL structure of your clay atom.

NAME _____

d. What has the probe told you about the atom?

_____

_____

3. The INNER area of the atom is called the NUCLEUS.

a. How does the nucleus differ from the electron cloud?

_____

b. How does this difference explain why most of the motion of an atom occurs in the electron cloud?

_____

SUMMARY/HOMEWORK

1. Explain why the number of electrons and the number of protons in an atom are equal to each other.

(Check your textbook for the following:)

2. How is the ATOMIC NUMBER of an atom determined?

3. How is the ATOMIC MASS of an atom determined?

FOR FURTHER THOUGHT

. If electrons are negative, and protons are positive, why aren't the electrons attracted to the nucleus and fall into it?

SPECIAL ACTIVITY SHEET

HOW DO ATOMS DIFFER?

NAME_____ CLASS_____ DATE_____

PROBLEM: How do atoms differ?

INTRODUCTION: If all matter is composed of similar atoms, how can we explain the many different types of matter that we find around us? How do we explain the variety of properties (color, texture, density, magnetism, etc.) that enable us to recognize the different materials that we find in our environment? How do we account for the various types of behavior we see among the elements? (Some are explosive, some quiet, some will melt easily, some will combine easily with others, etc.) We must conclude that these result from differences among the atoms themselves. Today you will study a selected group of atoms to determine some of these differences and how they affect matter.

PROCEDURE

Study the chart you were given with this Special Activity Sheet, and answer the following questions.

1. Each of the types of atoms shown on the chart represents a different ELEMENT. In your own words, write a definition of ELEMENT.

_____

_____

2. List some common elements with which you are familiar. DO NOT LIST THE ELEMENTS SHOWN ON THIS CHART.

_____

_____

3. Scientists have found 106 different elements as of 1982. How does the atomic structure of atomic number 105 differ from that of atomic number 106?

_____

_____

_____

NAME _____

EXAMINE THE ATOMS ON YOUR CHART

4. Make a list of those elements shown on the chart that you think would be most ACTIVE. (Remember the demonstrations with potassium and sodium at the beginning of lesson.)

_____

_____

_____

5. State at least one REASON why you think that the atoms that you have listed above are active elements.

_____

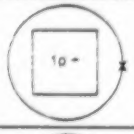
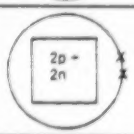
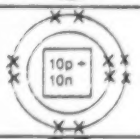
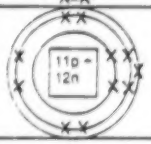
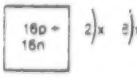
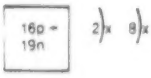
_____

_____

6. Each ring of electrons that surrounds the nucleus represents an energy level. What is the maximum number of electrons in each of the following energy levels?

Energy Level	Letter	Maximum Electron Number
1	K	
2	L	
3	M	
4	N	

NAME _____

TYPE OF ATOM	ATOMIC NO.	ATOMIC WT.	ATOMIC PICTURE (X=electron)
Hydrogen	1	1	 Gas molecule is H_2 Explosive
Helium	2	4	 Gas Does not burn
Lithium	3	7	Metal
Neon	10	20	 Gas Does not burn
Sodium	11	23	 Metal Can explode
Sulfur	16	32	 Nonmetal Yellow
Argon	18	37	 Gas Does not burn

SUMMARY/HOMEWORK

1. How does the structure of atoms differ?
2. How do differences in atomic structure help to explain the differences in the properties of elements?

FOR FURTHER THOUGHT

Draw atomic pictures for:

Fluorine	Oxygen	Magnesium
Atomic No. 9	Atomic No. 8	Atomic No. 12
Atomic Mass=19 units	Atomic Mass=16 units	Atomic Mass=24 units

ADDITIONAL IN-CLASSROOM ACTIVITY

HOW CAN WE USE THE PERIODIC TABLE?

NAME_____ CLASS_____ DATE_____

DIRECTIONS: Using your Periodic Tables, fill in all the spaces in the chart.

ELEMENT	SYMBOL	ATOMIC NUMBER	ATOMIC MASS	PERIOD	GROUP (FAMILY)	METAL, NONMETAL, OR NOBLE GAS
1. Zinc						
2. Krypton						
3. Antimony						
4. Lead						
5. Iron						
6.	Br					
7.	Sn					
8.	He					
9.		12				
10.		53				

LABORATORY WORKSHEET 2.4

NAME _____ CLASS _____ DATE _____

PROBLEM: How do we measure radioactive decay?

MATERIALS: Graph paper, ruler, pencil.

INTRODUCTION: Half-life is the amount of time required for one half of a quantity of radioactive material to decay. Each radioactive element has a half-life that is both specific and constant. Today you will use a graphing technique to determine the half-life of one radioactive element.

PROCEDURE

1. Prepare your graph according to the directions given by your teacher.

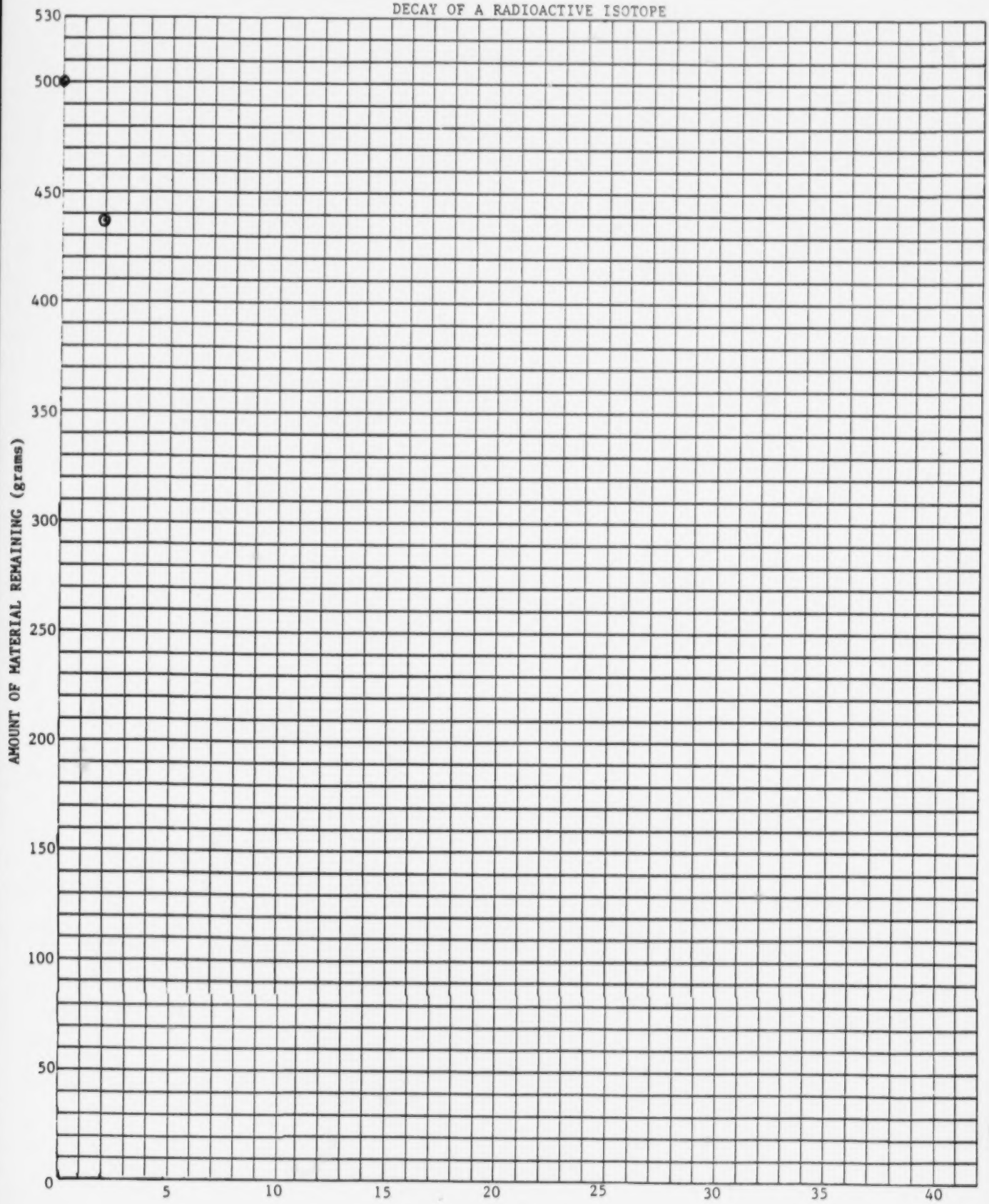
2. The columns of figures below represent results of experiments done to determine the half-life of radioactive iodine.

Time in Days	Grams of ^{131}I
0	500
2	437
4	375
8	250
12	187
16	125
20	93.5
24	62.5
28	47
32	31.3
36	23.5
40	15.7

Plot these data on your graph.

3. Draw a smooth line connecting the data points.

Name _____ Class _____


DECAY OF A RADIOACTIVE ISOTOPE
530
500
450
400
350
300
250
200
150
100
50
0
AMOUNT OF MATERIAL REMAINING (grams)
5
10
15
20
25
30
35
40
TIME IN DAYS

LABORATORY WORKSHEET 2.4 (continued)

NAME: _____

SUMMARY/HOMEWORK

1. How can this graph be used to determine the half-life of ^{131}I?

   _____

   _____

2. According to your graph, what is the half-life of ^{131}I?_____.

3. Predict the amount of ^{131}I remaining after ten days. How did you arrive at your answer?

   _____

   _____

LABORATORY WORKSHEET 2.5

NAME_____ CLASS _____ DATE_____

PROBLEM: How can we prevent heat loss?

INTRODUCTION Heat loss can be prevented by insulation. An insulator is a material that slows or controls the flow of heat. But how does insulation work? Today you will perform a series of activities to investigate this.

MATERIALS: For each group: index cards lettered B or W, Celsius thermometer, construction paper (black and white), ice, aluminum foil, newspaper, rubber band, insulated ice bucket, lamp.

PROCEDURE

1. Insulate your thermometer.

   a. For this activity you will be working with another group. Look in your equipment tray and find the card lettered B or W. A B and a W group should work together as a pair. Select your partners.

   b. Record the room temperature, in degrees Celsius, on the chart below in the column labelled "Initial Temperature." Be sure to take readings from both the B group and the W group thermometers.

Group	Initial Temperature	Final Temperature
W		
B		

   c. Carefully wrap your thermometer bulb with the construction paper on your tray (black or white). Secure it with a rubber band.

   d. Carefully place your thermometer on the table at the front of the room under the lamp. You will come back to this later in the period.

2. Insulate the ice.

   a. Take four ice cubes from the bucket at the front of the room and place them in the pan or tray at your table.

   b. Wrap one ice cube in aluminum foil so that the dull side of the foil faces outward.

LABORATORY WORKSHEET 2.5 (continued)

NAME _____

c. Wrap one ice cube in aluminum foil so that the shiny side faces outward.

d. Wrap one ice cube in crushed newspaper and then in aluminum foil with the shiny side out.

e. Leave one ice cube unwrapped.

f. After <u>five</u> minutes unwrap the ice cubes and observe them.

1. Which ice cube melted most? _____

2. In step 2e above, you left one ice cube unwrapped. Explain why you were asked to do this.

_____

_____

3. What do we call materials that prevent heat loss? _____

a. Take your thermometer from the front of the table and carefully remove the insulating paper.

b. Record the temperature readings on your chart in the column marked "Final Temperature." Be sure to record both the B and the W readings.

1. Do the initial and the final temperatures differ?
2. Using the results of today's activities, design an efficient insulator.
3. Why is a bulky down coat warmer than a thin woolen coat of the same mass?

<u>SUMMARY/HOMEWORK</u>

1. Why are substances with shiny surfaces better insulators than substances with dull surfaces?

2. Why is effective insulation important to the design of your home?

3. What are some effective insulating materials?

4. Take an inventory of the heat loss in a building such as your school. Make a list of the places from which heat is most likely to escape. Remember that heat can be lost by conduction, convection, and radiation. Recommend how you could reduce heat losses from the building and thus conserve energy.

LABORATORY WORKSHEET 2.6

NAME_____ CLASS _____ DATE_____

PROBLEM: How is heat different from temperature?

MATERIALS: Two styrofoam cups, two ice cubes, Celsius thermometer, stirring rod, water, beaker, graduated cylinder.

INTRODUCTION: An iceberg at 0°C contains more internal heat energy than a beaker of boiling water at 100°C. Today you will discover why.

PROCEDURE

1. Using the graduated cylinder, measure 30 ml of warm water and pour it into a styrofoam cup. Label this Cup No.1.

2. Using the graduated cylinder measure 100 ml of warm water and pour it into the second styrofoam cup. Label this Cup No.2.

3. Record the thermometer reading of the water in each cup on the data table below:

	Initial Temp	Final Temp	Change in Temp
Cup No.1			
Cup No.2			

4. Place an ice cube into each cup.

5. Stir the water in Cup No. 1 until the ice melts. Measure and record the temperature.

6. Stir the water in Cup No. 2 until the ice melts. Measure and record the temperature.

7. Complete the data table by determining and recording each temperature change.

   a. How did the temperature change in Cup No.1? Compare with the temperature change in Cup No.2.

_____

_____

_____

_____

LABORATORY WORKSHEET 2.6 (continued)

NAME _____

b. How can we explain the difference between the two temperature changes?

_____

_____

_____

_____

c. How is the amount of water related to the amount of heat that was transferred in each cup?

_____

_____

_____

_____

SUMMARY/HOMEWORK

1. What is the difference between internal heat energy and temperature?

2. Why does an iceberg at 0°C contain more internal heat energy than a beaker of boiling water?

LABORATORY WORKSHEET 2.7

NAME_____ CLASS_____ DATE_____

PROBLEM: How is heat measured?

INTRODUCTION: Heat energy is measured in units called calories. A calorie is the amount of heat that must be transferred to raise the temperature of one gram of water by one degree Celsius. Today we will be using a tin can calorimeter, which is an instrument used to measure heat.

MATERIALS: Celsius thermometer, candle, tin can calorimeter, 250 ml beaker, triple beam balance, water, graduated cylinder, ceramic (or other material) pads, tongs.

PROCEDURE

1. Calculate the total heat energy that can be produced by burning a paraffin candle.

   a. A candle produces approximately 10,000 cal/g. when it burns

   b. Using the triple beam balance determine the mass of your candle (in grams). _____g.

   c. The total energy your candle can produce is _____ calories.

2. Measure the heat energy coming from your candle.

   a. Using the graduated cylinder, measure 25 milliliters of water and pour it into your beaker. The water mass is_____g.

   b. Determine the temperature of the water in the beaker. _____°C

   c. Shape the clay at your table into a candle holder by pressing the bottom of the candle into it. Place on a ceramic pad.

   d. Making sure that the candle is firm in its holder, light it and CAREFULLY lower the tin can calorimeter over the lighted candle.

   e. Place the beaker with water on top of the tin can. Hold the thermometer in the beaker and allow the water to heat for five minutes. The water temperature at the end of five minutes is _____°C.

   f. Quickly and carefully:

      1. Remove the thermometer.
      2. Move the beaker to a ceramic pad on your desk.
      3. Lift the tin can with your tongs.
      4. Blow out the candle.

   g. Remass your candle. Its mass is now_____g.

LABORATORY WORKSHEET 2.7 (continued)

NAME _____

SUMMARY/HOMEWORK

1. Do the arithmetic.

   a. The heat from the candle caused a change of _____ °C in the water.

   b. Calculate the amount of heat absorbed by the water. _____ calories

      Heat (calories) = mass of water (g) x change of temperature (°C)

   c. The heat energy given off by the candle is equal to _____ calories.

      (Calories of candle wax = change in mass of candle x _____ cal/g)

2. Why is the number of calories given off by the candle greater than the number of calories absorbed by the water?

LABORATORY WORKSHEET 2.8

NAME_____ CLASS _____ DATE_____

PROBLEM: How do mirrors differ from lenses?

INTRODUCTION: An image is produced by a lens when the rays of light pass through the glass of the lens. An image is produced by a mirror because the rays of light cannot pass through it. Today you will construct a mirror from a lens to see why this is true. You will also be studying the mirror reflections to learn the characteristics of these images.

MATERIALS: Aluminum foil, flat piece of glass, convex lens, plane mirror.

PROCEDURE

1. Study the flat piece of glass on your table.

   a. How does the shape of this differ from that of convex and concave lenses?

   _____

   b. Hold the glass up toward the window and look through it. Describe what you see.

   _____

   c. How do we know that light must travel through the glass?

   _____

2. Study your reflection in the sheet of aluminum foil on your table. Why is this said to have a mirror surface? DRAW A DIAGRAM ON THE BACK OF THIS LABORATORY WORKSHEET PAGE TO EXPLAIN YOUR ANSWER.

   a. Hold the foil up towards the window. What do you observe looking through the foil?

   _____

   b. Why doesn't the light from the window pass through the foil?

   _____

   c. What happens to the light rays that do strike the foil?

   _____

LABORATORY WORKSHEET 2.8 (continued)

NAME _____

d. Using the foil and the flat piece of glass, construct a conventional mirror. Why is this a better mirror surface than foil alone?

_____

A MIRROR IMAGE

1. Study the commercial mirror on your table. Why are its reflections CLEARER than those seen on your homemade mirror?

_____

2. Try to touch your image on the surface of the mirror. Are you able to reach your image?

_____

3. Move the mirror closer to you. Now move it away. What happens to the distance between you and your image? (Study the mirror carefully as you move it.)

_____

4. How far behind the mirror does the image appear to be?

_____

_____

5. Move the mirror to the left. Now move it to the right. While looking into the mirror, move yourself to the left. Now move to the right. In what direction does the image move in each case?

_____

6. From what you have done so far, describe the MIRROR IMAGE.

_____

_____

SUMMARY/HOMEWORK

1. How are distortions created in a hall of mirrors?

2. What is meant by the term "mirror image"?

LABORATORY WORKSHEET 2.9

NAME_____ CLASS_____ DATE_____

PROBLEM: How are mirrors used?

MATERIALS: Shiny metal spoon.

INTRODUCTION: Mirrors have many uses in the home, stores, and vehicles. They play an important role in our daily activities. The interaction between light and mirror follows definite laws of science. Today we will reflect on mirrors and their uses and properties.

DEVELOPMENT

1. How does the spoon resemble a pocket mirror?

_____

_____

2. Study the rounded back of the spoon.

   a. Why can you see yourself reflected here?

   _____

   b. Describe your image in the spoon.

   _____

   c. How does this image differ from one you see in a PLANE mirror?

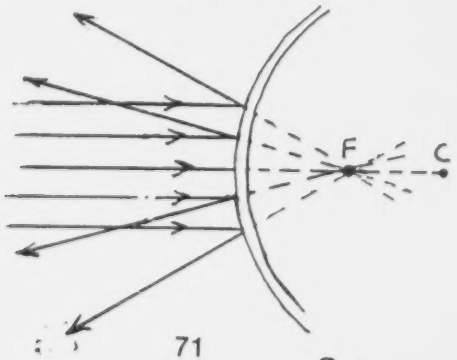
   _____

   d. How do you know that this side of the spoon's surface is a CONVEX reflecting surface?

   _____

   e. Study the image formed in the large convex mirror. Then study the diagram below:

CONVEX MIRROR



f. Why does a convex mirror always make an image that is smaller than the object?

_____

g. How are convex mirrors used on autos? _____

How do they help prevent shop lifting in large stores? _____

_____

h. What are some other uses of convex mirrors?

_____

3. Study the bowl of the spoon.

a. Turn the spoon around and compare the images formed on the convex back surface and in the bowl. How does your bowl image differ from that formed on the convex back? Which image is larger? Which is inverted?

_____

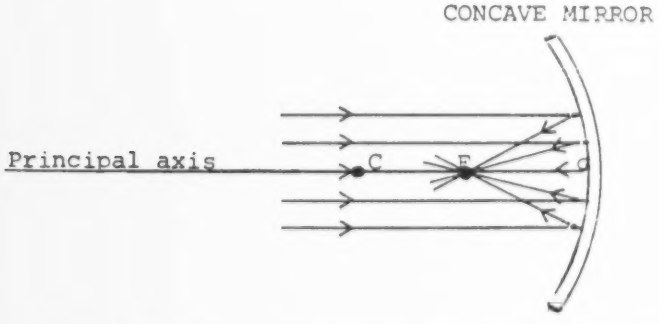
b. Why is the spoon bowl called a CONCAVE reflecting surface?

_____

c. How does your image in the bowl differ from that seen in a PLANE mirror?

_____

d. Study the diagram below:



e. Explain how a concave mirror can sometimes make the image appear larger than the object.

_____

f. Design a telescope (on the back of this laboratory worksheet page) that uses a concave mirror instead of a lens.

g. What are some other uses for concave mirrors?

_____

_____

4. Make a drawing of a mirror that is part concave and part convex. Draw an object and the image formed by such a mirror.

Where have you seen mirrors of this type? _____

_____

5. What are some other uses for plane mirrors? Why do home decorators often place large mirrors in dimly lit rooms?

_____

6. Make a list of optical instruments that might use mirrors instead of (or in addition to) lenses.

_____

_____

SUMMARY/HOMEWORK

. Why do some reflecting telescopes use both concave and plane mirrors?

_____

_____

LABORATORY WORKSHEET 2.10

NAME_____ CLASS_____ DATE_____

PROBLEM: How can we construct a refracting telescope?

INTRODUCTION: Spotting telescopes are instruments used to bring far-off objects into close view. The properties of light and lenses are used to focus and enlarge objects too distant for detailed study with the unaided eye. Today you will be assemble such an instrument. See if you can discover how and why your telescope works.

MATERIALS: Meterstick with desk stands, 15 cm focal length glass lens, 30 cm focal length glass lens, screen, screen holder, two lens holders.

PROCEDURE

I. Before you begin:

A. Examine the lenses you have been given. These are called converging lenses. Describe their surfaces and draw a diagram.

_____

_____

_____

_____

B. Hold up one lens so that light passes through it to your eye.

1. How does it affect your view? _____

_____

2. How does the view change as you move the lens closer to your eye?

_____

3. Look at both lenses. How do they differ from each other?

_____

C. How does the view change as you move the lens away from your eye?

_____

LABORATORY WORKSHEET 2.10 (continued)

NAME _____

II. Constructing your telescope.

A. Mount the meterstick on the stands.

B. Mount the screen near the center of the meterstick.

C. Using a lens mount, place one lens on the meterstick in front of the screen.

III. Select a fairly large and distant object, such as a tree or house outside the classroom window. Move your lens back and forth until you see the clearest possible picture of the object on your screen.

A. How does the image on the screen resemble the original object?

_____

_____

B. Describe how the image differs from the original object and draw a diagram.

_____

_____

_____

C. Carefully measure and record the distance between the screen and the lens. This distance is the focal length of the lens.

Focal length of the lens is _____ cm.

IV. Replace lens 1 with lens 2. Repeat the same procedure with lens 2 placed at the opposite end of the meterstick.

Focal length of second lens is _____ cm.

V. Now place both lenses at the proper focal lengths on opposite sides of the screen. Observe the object on the screen through the lens with the small focal length.

VI. Without touching the lenses, remove the screen from the stick and look through the eyepiece. Describe what you see.

_____

_____

LABORATORY WORKSHEET 2.10 (continued)

NAME _____

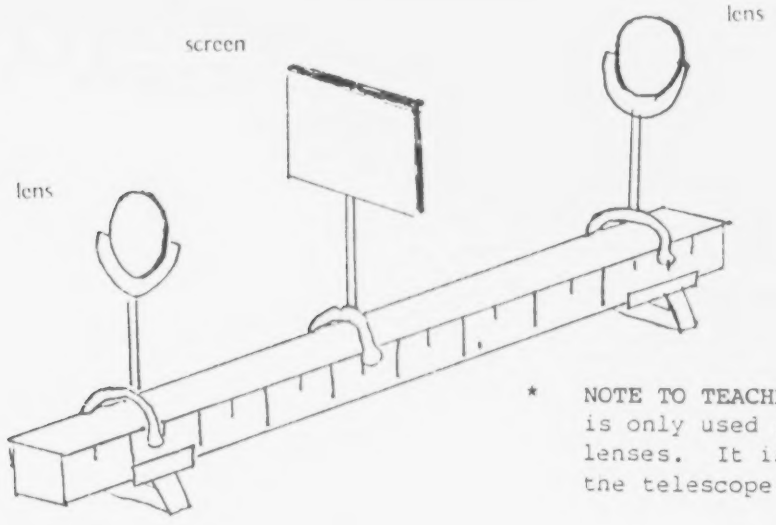
VII. Turn your telescope around and use the eyepiece lens as the objective lens. Describe how the image changes and draw what you see.

_____

_____

_____

_____



* NOTE TO TEACHER: The screen is only used in focusing the lenses. It is removed to use the telescope.

SUMMARY/HOMEWORK

1. Why are two lenses used in the construction of the telescope?

_____

2. What happens when you move the two lenses closer together?

_____

3. What happens when you move the two lenses farther apart?

_____

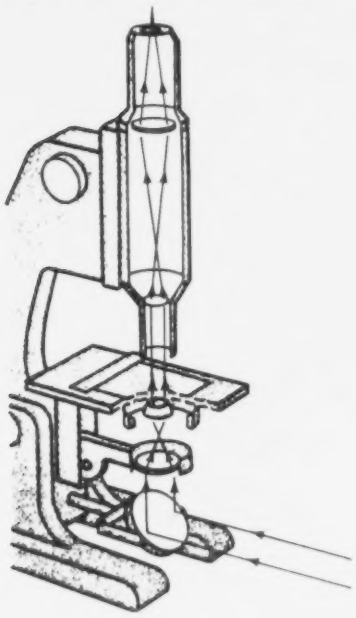
4. Why do we use a telescope to observe distant objects?

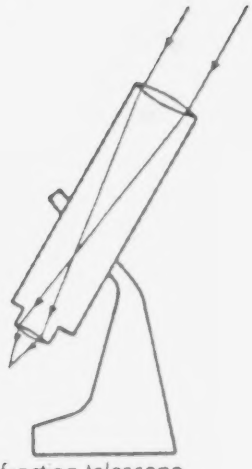
_____

5. Why are the lenses of the telescope enclosed in a tube?

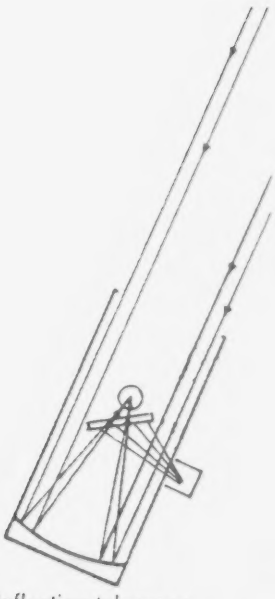
_____

Light rays in a microscope





Refracting telescope



Reflecting telescope

Jay M. Pasachoff, Naomi Pasachoff, and Timothy M. Cooney, Physical Science (Glenview, Ill.: Scott, Foresman and Co., 1983), pp. 307-308.

LABORATORY WORKSHEET 2.11

NAME_____ CLASS_____ DATE_____

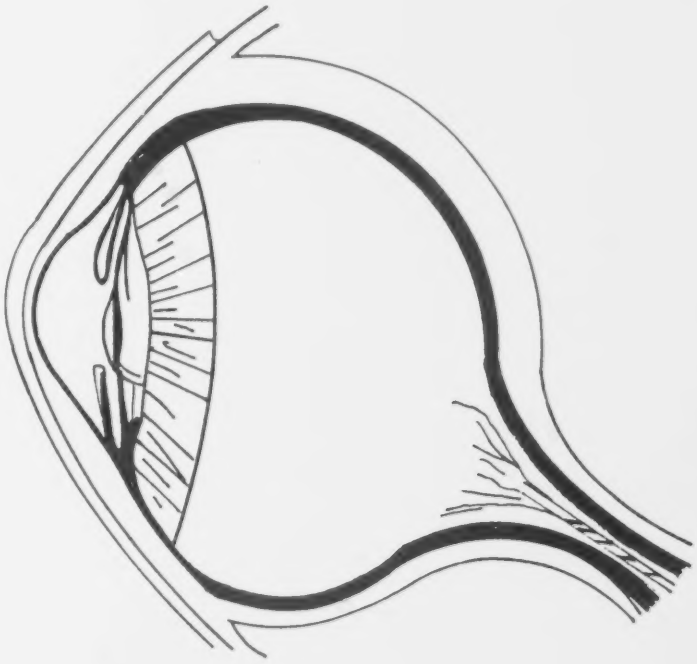
PROBLEM: How can we map the retinas of our eyes?

MATERIALS: Index card with colored dots.

INTRODUCTION: The retina is often called the screen of the eye. It is here that different light rays and colors are detected. It is here that images form. It is here that "nerve fibers" gather the "messages" that transmit our sight to the brain. Today we will study the retinas of our eyes to learn about the sights in our lives.

PROCEDURE

1. Identify the areas on the retina where total vision, color vision, and distinct vision are detected. Also identify the blind spot where the ends of the optic nerves are located.



2. Determine the range of your vision:

   a. TOTAL VISION: Close your left eye and stare straight ahead. Now, hold a pen at arm's length and move it to the right until you can no longer see it. Repeat the procedure with your left eye.

      -- What is meant by your range of total vision? _____

      _____

      -- Let's mark the range of total vision on the retina. (Wait for teacher directions.)

NAME _____

b. DISTINCT VISION: Close your left eye and stare straight ahead. Hold this paper at the outer limits of your visual range. Slowly, move the paper toward you until you can read it clearly. (Use only one eye.)

-- How does your range of distinct vision compare with your range of total vision?

_____

_____

-- Now map the area of distinct vision on the retina. Why must an object be directly in front of you before you can see it clearly?

_____

_____

c. COLOR VISION: Close your left eye. Using the card with colored dots that you have at your table repeat Step 2 of the above procedure.

-- Which color do you recognize first? _____

-- Which is the second color that you see clearly? _____

-- Which color comes into view last? _____

-- Why do you see the dots in black and white before you recognize them in color?

_____

_____

Let's now map the color area on your retina.

3. Finding the blind spot:

Find the illustration of a rabbit and a hat. Hold the paper about 30 centimeters from your face. Close your right eye. Look at the rabbit with your left eye. Move the paper back and forth until the hat disappears. This is the blind spot of your left eye.

LABORATORY WORKSHEET 2.11 (continued)

NAME_____

a. On the eye diagram on this Laboratory Worksheet, circle the area of the retina where you think the blind spot occurs. State <u>one</u> reason for your choice.

_____

_____

b. To find the blind spot of your right eye, repeat the above with your left eye closed. This time, stare at the hat and move the paper until the rabbit disappears.

<u>SUMMARY/HOMEWORK</u>

1. Describe the role(s) of the (a) lens, (b) eye muscles, (c) retina, in producing your sense of vision.

2. Explain why you can see an object best when it is directly in front of your eyes.

LABORATORY WORKSHEET 2.12

NAME:_____ CLASS_____ DATE_____

PROBLEM: How can we discover which material is the best sound transmitter?

MATERIALS: Tuning fork, rubber stopper, wooden dowel, plastic ruler, sponge, board eraser, glass rod, metal rod (tripod leg), string, 2 tin cans or paper cups with holes punched in the closed ends.

PROCEDURE

1. Develop with your teacher and class, and then with your laboratory group, a method for testing and comparing the ability of materials to transmit sound.

2. Perform the activities and complete the following table. What type of rating scale will you use?

MATERIAL	ABILITY TO TRANSMIT SOUND

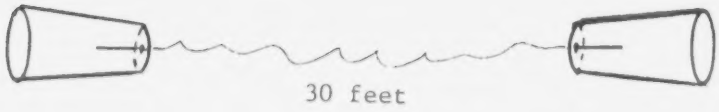
a. What were some variables or possible sources of errors in your experiment? Explain.
b. How might such variables be eliminated or CONTROLLED?

LABORATORY WORKSHEET 2.12 (continued)

NAME _____

3. Obtain 2 paper cups or tin cans. Punch a small hole in the center of the bottom of each.

   a. Using about 30 feet of string, thread the ends through the holes and knot them.



   b. Stretch the string tightly and do not allow it to touch anything.
   c. Without using your cup, whisper to your friend who is holding the other end of the thirty-foot string. Can your friend hear you?
   d. Now, whisper into your cup while your friend places his/her cup to his/her ear. Why is it easier for your friend to hear you?

SUMMARY/HOMEWORK

1. Based upon your laboratory activities, what do you conclude?

2. Briefly discuss some experimental variables in your procedures.

3. How does the Kinetic Molecular Theory help to explain your results?

4. How did using the cup affect your friend's ability to hear you? Explain.

5. Compare the speeds of sound in different solids, liquids, and gases.

LABORATORY WORKSHEET 2.13

NAME_____ CLASS_____ DATE_____

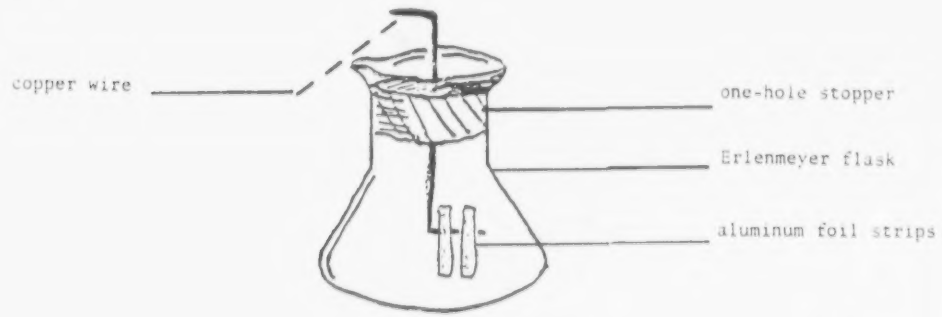
PROBLEM: What is static electricity?

MATERIALS: Copper wire, two strips of aluminum foil, Erlenmeyer flask, one-hole stopper, comb, pieces of paper, glass rod, piece of silk.

INTRODUCTION: Why do you sometimes get a shock when you touch a metal object after walking across a carpeted room? Why do clothes sometimes cling together when removed from a clothes dryer? Today we will become acquainted with the behavior of the charged particles that are responsible for these phenomena.

PROCEDURE

1. Insert the copper wire through the stopper. Bend both ends at right angles to the rod. Hang the two leaves of aluminum foil at one end. Insert the cork in the Erlenmeyer flask. This setup is called an electroscope. Check your setup against the diagram below:



Touch a comb to the exposed end of the copper wire. Why don't the aluminum leaves react to the comb?

_____

_____

2. Comb your hair about 20 times. Then touch the copper wire with the comb.

How does this affect the positions of the aluminum leaves?

_____

_____

LABORATORY WORKSHEET 2.13 (continued)

NAME _____

3. Touch the copper wire with your finger.

   a. How do we know that the aluminum leaves were uncharged (neutral) at the start of the experiment?

   _____

   _____

   b. What was the effect on the aluminum foil of the electrons that were removed from your hair by the comb?

   _____

   _____

   c. Why did the aluminum leaves come together when you touched the copper wire with your finger?

   _____

   _____

   d. Predict what will happen if you bring the comb near your hair after you comb it.

   _____

   _____

   Test your prediction.

4. Tear a sheet of paper into small pieces. Comb your hair and bring the comb close to the pieces of paper.

   Record your observations.

   _____

   _____

5. Rub a lucite or plexiglass rod with a piece of silk to build up a charge. Use some pieces of paper to see if this produces a similar action as the charged comb near the electroscope. What happens?

   _____

   _____

LABORATORY WORKSHEET 2.13 (continued)

NAME _____

SUMMARY/HOMEWORK

1. How can you protect yourself from a shock after walking across a carpet?

2. How did you show that electrons can produce work?

3. What is meant by "static cling"?

4. Why must computers be protected against static electricity?

FOR FURTHER THOUGHT

. Why is an uncharged object attracted to a charged rod initially, but repelled by it after contact is made with the rod?

LABORATORY WORKSHEET 2.14

NAME_____ CLASS_____ DATE_____

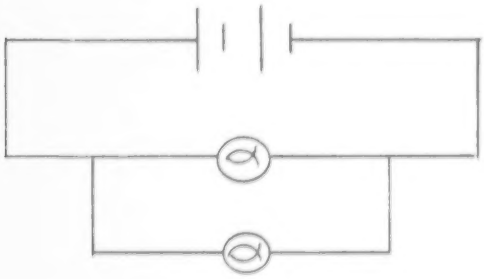
PROBLEM: How can the flow of electricity be changed?

MATERIALS: Two 1.5 V dry cells, insulated bell wire, two bulbs, two sockets, switch.

INTRODUCTION: Picture an apple pie. Most of us "see" the same thing. Now picture water flowing. Some of us might "see" a narrow, rapidly-moving mountain stream while others a wide, slow-moving river. Many factors can affect the flow of water. The flow of electricity can also be affected by a variety of factors. You will discover some of these factors today.

PROCEDURE

1. Set up a circuit using the diagram below as a guide.



Note: Always place the switch in the open position when you are not making observations.

a. What is a complete circuit? _____

_____

b. Why may the battery be considered as the driving force of the circuit?

_____

_____

LABORATORY WORKSHEET 2.14 (continued)

NAME _____

2. Set up a circuit using two batteries connected in series to one bulb.

   a. How does the brightness of the bulb here compare to the bulb in procedure 1?

   _____

   b. How can you explain the difference in the brightness of the bulb compared to procedure 1?

   _____

   _____

3. Set up a circuit using two batteries and two bulbs, all connected in series.

   a. Compare the brightness of the bulbs in this step to that of the bulbs in procedures 1 and 2.

   _____

   b. In what way has the bulb's brightness changed?

   _____

   _____

4. Now partially unscrew one bulb.

   a. How does this affect the brightness of the other bulb? _____

   _____

   b. How is this similar to Christmas tree lights connected in series?

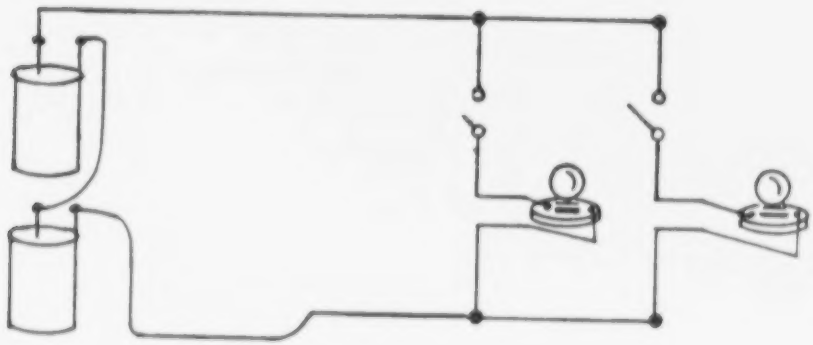
   _____

   _____

5. Try to make a circuit such that when one bulb goes out the other remains on. Use 2 bulbs and 2 dry cells. What is a parallel circuit? Review parallel circuits as circuits that provide more than one path for electrons to flow. (Refer to Grade 7 Curriculum Guide, pp. 91-92.)

LABORATORY WORKSHEET 2.14 (continued)

NAME _____



SUMMARY/HOMEWORK

1. Why does varying the thickness of a copper wire affect the flow of electrons?

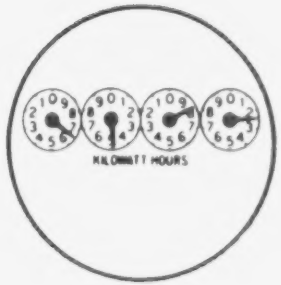
2. Why don't all the lights in your house go out when you unscrew one?

FOR FURTHER THOUGHT

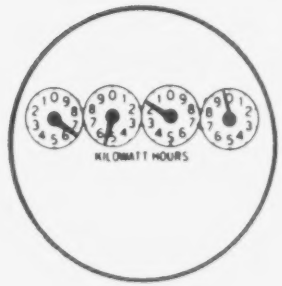
. Why is tungsten wire used in bulbs rather than copper wire of the same thickness?

Electric

A



B



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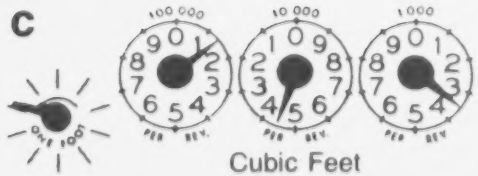
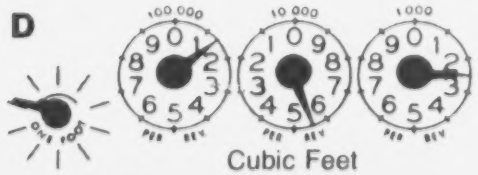
Meet Your Meters (pamphlet), Con Edison, New York, November 1981.

Gas

C



D



How to Read Your Electric Meter

You can read your own electric meter.

It has four dials, as shown in illustration "A" at the left. Start with dial on the left. The hand has passed 6 and is on its way to 7, so you read it as 6. You always read the smaller number. On the second dial the hand is not quite on 5, so you read it as 4. On the third dial the hand has not reached 9, so you read it as 8. On the fourth dial, the hand is between 2 and 3, so you read it as 2.

You'll note that the hands on the first and third dials move counterclockwise. The hands on the second and fourth dials move clockwise. In any case, just remember that the hands always move in the direction of the higher numbers.

The reading you get from the dials is 6-4-8-2. You write the figures down just as you read them from dial to dial, left to right.

At a later time, the meter dial hands have moved because some electricity has been used. Here, the dial hands are in the positions of those in illustration "B." This reading is 6-5-1-9. You might ask, why read the hand on the third dial as 1 when the hand looks like it is on 2? Because the hand on a dial moves fully from one number to the next only when the hand on the next dial to the right has made a complete turn from 0 to 0. The hand on the right has not made a complete turn—it had just passed 9 but is short of 0. So the hand in question on the third dial has not quite reached 2.

So how much electricity has been used?

The difference between the two meter readings—6519 and 6482—represents the amount used in this case. Subtracting 6482 from 6519 gives 37, the measure of the amount used in the time between the two readings.

On some meters, the difference between the readings must be multiplied by another figure—usually 10—to get the actual number of kilowatthours (kwh) used. This is because the hand on the last dial on the right, as in this example, advances one number for every 10 kwh used. The multiplier figure is shown on your bill. In this reading with the multiplier number of 10, the total kwh would be 370 (37 times 10).

How to Read Your Gas Meter

Gas meters have a row of three or four dials (see illustration "C" at left with three dials—the kind on most gas meters). Other smaller dials below the row and marked with the words "one foot" (usually one dial, but sometimes two) are used for testing only, so you don't have to read them or pay any attention to them. You read the row of dials—either three or four, depending on which meter you have.

Start with the dial at the left in illustration "C" and read the last, or smaller, number passed by the hand—in this case 1. You read the second dial as 4, because the hand is between 4 and 5. In the same way you read the next dial as 3.

The dials from left to right read 143—your gas meter reading. A later reading may come to 152 as in illustration "D."

How much gas have you used?

By subtracting the first reading—143—from the second—152—you get 9, which is the number of units of 100 cubic feet, or a total of 900 cubic feet of gas you have used.

LABORATORY WORKSHEET 2.15

NAME_____ CLASS_____ DATE_____

PROBLEM: What are some properties of coal?

INTRODUCTION: Coal is the most abundant source of fossil fuel energy in the United States. In this investigation, you will take a close look at several types of coal. You will see evidence of how it was formed.

MATERIALS: Chunks of peat moss, bituminous coal, anthracite, newspaper or paper towels, hammer, coarse white paper, triple beam balance.

PROCEDURE

1. Cover your work area with newspaper or paper towels. Take care to protect your clothing.

2. Examine a piece of each type of coal and complete the chart below:

Name	Color	Texture	Hardness	Special Features
Peat				
Bituminous coal				
Anthracite coal				

3. Rub a sample of each on a piece of white paper.

   a. Why is peat considered to be an early stage in the development of coal?

   _____

   _____

   b. What evidence did you find to show that coal is formed in layers?

   _____

   _____

LABORATORY WORKSHEET 2.15 (continued)

NAME _____

4. Mass 20 g of each form of coal.

   a. Which sample has the greatest volume?_____

   b. In which sample are the molecules the farthest apart?_____

   c. The relationship between an object's mass and its volume can be expressed using the equation:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

   How would you explain why 20 g of anthracite is more dense than 20 g of peat?

_____

_____

SUMMARY/HOMEWORK

1. Why would a shoe box filled with cotton be less dense than the same shoe box filled with buttons?

_____

_____

_____

_____

2. How could Superman change peat moss into coal?

_____

_____

_____

_____

3. Since one gram of water occupies a volume of 1 cm^3, its density is said to be 1 gram per cm^3. What would be the density of 100 grams of water under the same conditions?_____

STUDENT POLL ON NUCLEAR ISSUES

NAME _____

Directions: Place a check (/) in the column that most closely represents your opinion on each of the nuclear issues stated below.

NUCLEAR ISSUES	Agree	Strongly Agree	Disagree	Strongly Disagree	Not Sure
1. The most pressing global issue of our time is the threat of nuclear war.					
2. Someday, somewhere, someone will "push the nuclear button."					
3. In war, the use of any weapon, including nuclear weapons, is justified.					
4. The decision to use nuclear weapons should be based on military and political rather than moral consideration.					
5. Considerations of morality (right and wrong) should influence scientists when they develop new weapons.					
6. The Soviet Union today is superior to the United States in nuclear weapons.					
7. The Soviets are out to conquer the world.					
8. The United States should destroy the Soviets rather than allow communism to spread.					
9. When the Soviets build more and better nuclear weapons, the United States must do the same.					
10. Today it is possible to wage a "limited" nuclear war.					

STUDENT SHEET

WATER TEMPERATURE IN A LAKE

Algae in Lakes

Algae, which are simple plants, provide a source of food for simple, plant-eating lake animals. Algae in a cool water lake may include: green algae, blue-green algae, and diatoms. Diatoms in particular provide a good source of food for algae-eating orgnaisms. Blue-green algae, on the other hand, can produce a bad smell and taste in the water. A good supply of algae will provide plant-eating animals with an adequate food supply. These animals will in turn be eaten by larger and larger animals--smaller fish, larger fish, frogs and turtles.

Water Temperature Preferences of Lake Animals

Some lake animals can survive a wide range of water temperatures, while other animals require a very specific water tempertaure. Animals will try to locate themselves in a lake according to these temperature needs. Trout, for example, need cold water, while many young fish (minnows, for example) are found in the warmer waters. Since colder water is more dense than warm water, colder water is usually found at the bottom of a lake and warmer water is found near the surface or in the shallow areas.

The Effect of Increased Water Temperature on Life in a Lake

The addition of heat energy to a lake will warm the water and thereby extend the active growing season of the plants living in the lake. The additional heat will also speed up the metabolism and other life functions of these organisms. Their faster growth rate eventually results in an increased death rate.

The Effect of Temperature on Gases Dissolved in Water

Cold water can usually hold more dissolved gases (air, oxygen, carbon dioxide, etc.) than warmer water. As a body of water warms it loses more and more of its dissolved gases. The loss of dissolved oxygen will affect fish and other animals that depend on this oxygen supply. Similarly, the loss of dissolved carbon dioxide may have a harmful effect on the growth of aquatic plants. Therefore, the death rate of these organisms will increase. Bacteria will use up even more of the dissolved oxygen as they decompose the dead bodies of fish and other organisms.

Student Sheet

THE ELECTRIC ATOMIC PLANT

The plant would be a modern atomic power station producing 50% more waste heat than a conventional plant. There will be no smoke, dust, or odors given off as in normal coal, oil, or gas units. The plant will use lake water to cool its steam unit and return the water to the lake about 25° hotter causing the overall lake temperature to rise 1°F.

There are two other ways the plant could cool off its equipment besides direct flow. These are the cooling pond and cooling tower methods. The direct flow method uses large quantities of lake water and is the least expensive method. All the excess heat would go into the lake, but this method would keep the cost of building and operation down.

The cooling pond method uses a large man-made lake or pond filled with water taken from the lake by pumps. These very large ponds require large amounts of land to be purchased, dug out, and flooded at great expense. The water from the deep end would go into the plant and hot water would be pumped into the shallow end allowing it to cool off before it goes back to the deep end. This could affect the natural water table and requires a very special type of geologic land structure.

Cooling towers can be used to cool water in atomic plants. In the dry cooling tower, hot water is pumped through closed pipes with fans on them. As fans blow air past these pipes the heat is allowed to transfer into the air. In wet cooling towers, heated water is pumped and sprayed over metal plates. As air is forced by fans over the plates the water evaporates and is cooled. These towers do not affect the temperature of the lake but do change the atmosphere by adding heat and/or water vapor. A wet tower costs about 25 million dollars to build and a dry tower 50 million dollars. These very high costs would have to be passed along to the user.

ENVIRONMENTAL DATA SHEET

LAKE DATA

The lake is a very small one, with very little water movement. It supplies drinking water for the community. The algae grows near the surface for seven months of the year. Sunlight penetrates the water to a depth of four feet, with summer temperatures of 21°C. The cool temperature allows for a good supply of dissolved oxygen and carbon dioxide. There is an overpopulation of biomass in the lake which is causing it to fill up as the living matter dies. The presence of algae causes the water temperature to be a little high due to the sun's rays being absorbed.

Industrial and farming waste supplies the lake with large quantities of growth materials causing the lake to age rapidly. This has caused the clear water depth to become one half what it was 20 years ago. The lake is used for recreation, city and industrial sewage.

The present electrical power plant uses the lake water to cool it through pipes at the 50 foot level of the lake. The new proposed plant would double that depth and use up to seven times the amount of water.

ECONOMIC DATA

To construct the plant local workers and materials would be used wherever possible. This means an influx of 40 million dollars into the community. The construction would give 1,500 workers employment after the plant was put into operation. The payroll would be about 20 million dollars and the supplies would cost 25 million dollars. The city would receive new tax monies.

The cost of electricity would remain at a low level giving an opportunity for influx of new industry and business.

NRC To Hear Final Testimony, Plans Long-Range Study

Recommendation to Come on Whether Plants Under Construction Will Be Halted

The Nuclear Regulatory Commission will hear final testimony in its hearings on whether or not to permit the construction of new nuclear power plants.

The NRC has been listening to nuclear power experts to determine if the risk to civilian health and safety warrants a halt to new plant construction.

Recent incidents and shutdowns of nuclear power facilities prompted the NRC to study the safety of all nuclear plants.

Antinuclear groups are concerned about meltdowns and nuclear fallout that would endanger the lives of thousands of people in communities surrounding the plants. Antinuclear groups are also concerned about nuclear waste disposal. There have been claims of slight radioactive contamination of drinking water and emissions into the atmosphere near waste disposal sites.

The nuclear industry stands on its record of no deaths or threats to life from any plant accident. Pronuclear experts have also stated that all radiation emissions from plants, planned or accidental, have been far below strict federal standards for safety. European countries have demonstrated successful nuclear waste disposal techniques, pronuclear scientists have explained. The industry feels that nuclear power is extremely necessary if the U.S. is to be energy self-sufficient.

Some angry antinuclear forces are questioning whether there are *any* safe levels of radiation.

The NRC must decide today whether to prohibit the construction of new plants, shut down all current plants as well, or allow their industry to continue as is.

Representatives from the nuclear industry and antinuclear groups will argue their case before the NRC board today. The board is then expected to make one of the following decisions:

a) If the NRC agrees with antinuclear groups and decides to shut down all current plants and prohibit construction of any future ones, the U.S. will have 0 units of nuclear power available for energy use.

b) If the NRC permits only plants that have excellent safety records to remain in operation, the U.S. will have 10 units of nuclear power.

c) If current plants are allowed to continue operating, but future plants are prohibited, the U.S. will have 20 units of nuclear power.

d) If the NRC decides in favor of the nuclear industry after reviewing its record and approves construction of new plants and continued operation of current ones, the U.S. will have 30 units of nuclear power for its energy needs.

News Bulletin, Institute of Lifelong Learning (Long Beach, Ca., 1980).

STUDENT SHEET

Careers in the Field of Energy

Branch	4-year degree grad. school	2-year degree	High School degree
OIL	engineers scientists chemists geologists geophysicists	engineering technicians engineering technologists lab technicians	oil well drillers welders iron workers cooks messengers, etc.
COAL	mining engineers chemists analytical chemists environmental engineers mine safety inspectors coal gasification engineers	engineering technicians engineering technologists lab technicians	miners truck drivers laborers
SOLAR	electrical architects design architects environmental engineers civil engineers	architectural technicians engineering technologists	sheet metal workers plumbers electricians iron workers welders
NUCLEAR	nuclear engineers electrical engineers radiation chemists nuclear physicists health physicists mathematicians radiological physicists radiological chemists	radiator monitors nuclear reactor operators radiographers radioisotope production operators	pipefitters electricians carpenters welders
ELECTRIC POWER	electrical engineers power engineers mechanical engineers design engineers environmental engineers nuclear engineers nuclear physicists environmental scientists civil engineers	engineering technologists engineering technicians lab technicians environmental workers	boilermakers sheet metal workers electricians welders

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